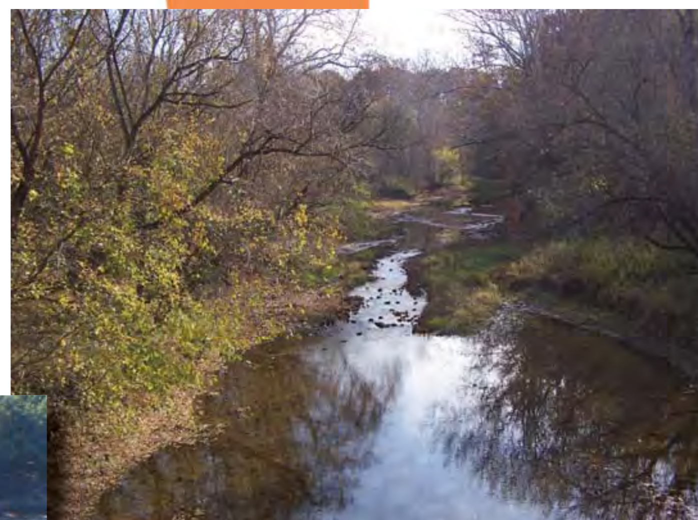
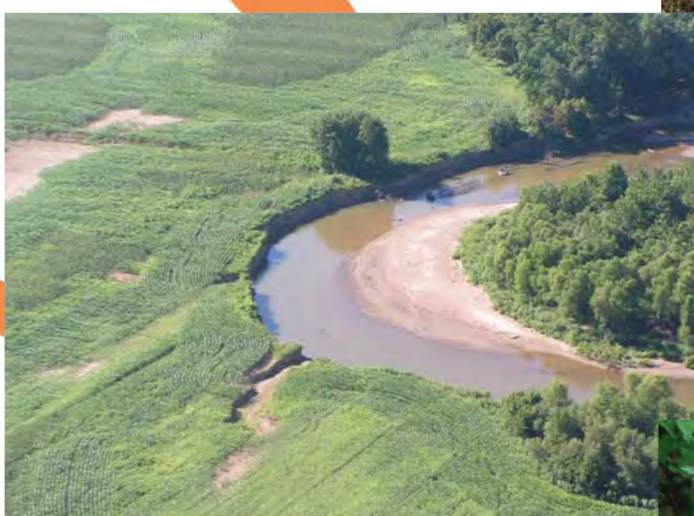
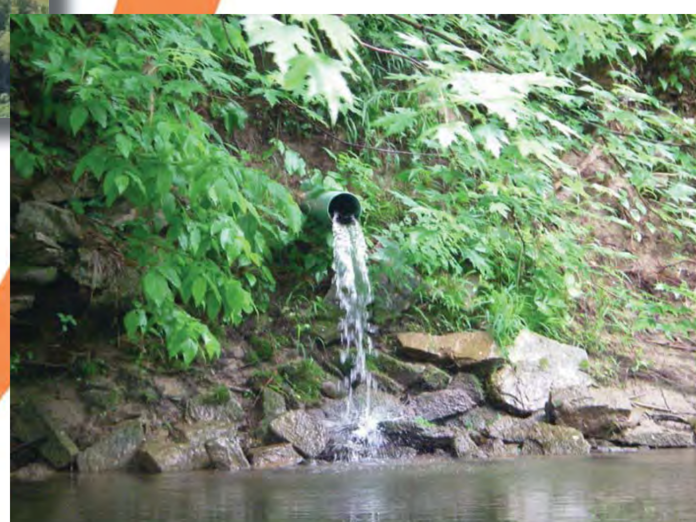
# Big Walnut Creek Watershed Management Plan







Putnam County SWCD
Empower Results, LLC

January 19, 2009

# TABLE OF CONTENTS

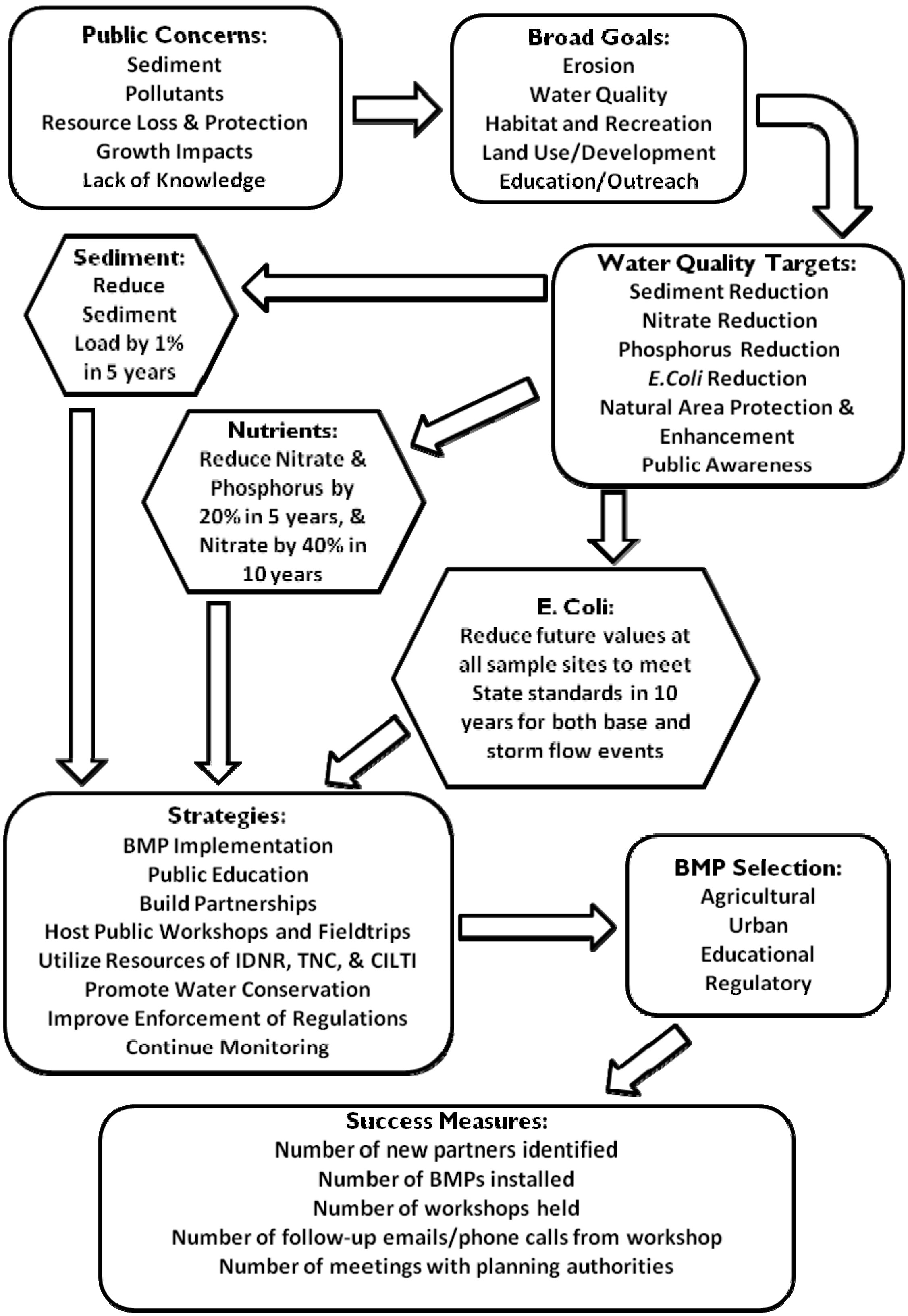
TABLES



FIGURES

APPENDICIES

# 1.0 EXECUTIVE SUMMARY



## 2.0 INTRODUCTION

The Big Walnut Creek Watershed Management planning process was initiated by the Putnam County Soil and Water Conservation District (SWCD). A variety of local land use and water quality concerns exist throughout the watershed. The interconnected nature of these concerns, as well as the desire to protect local natural resource assets, led the Putnam County SWCD to explore funding for a comprehensive watershed management plan that would lead to a strategic approach for conversation and restoration in the watershed.

### 2.1 Local Leadership

The following watershed management plan and assessment was funded via a Section 319 grant from the Indiana Department of Environmental Management (IDEM). While the Putnam County SWCD oversaw the grant administration, decisions related to the planning process were arrived at via consensus and collaboration among a diverse Steering Committee with multi-county representation. Technical aspects of this project were guided by a Watershed Coordinator and associated team of environmental consultants from Empower Results, LLC.

**The Steering Committee**

The Steering Committee was comprised of individuals from the following organizations:

Boone County SWCD
Hendricks County SWCD
Putnam County SWCD
Natural Resource Conservation Service
Putnam County Board of Health
Hendricks County Surveyor/Clean Water Department
Sycamore Trails RC&D
Putnam County Extension
Greencastle Water Works
Putnam County Planning & Zoning
Area 30 Career Center – DePauw University
Putnam County Commissioners
The Nature Conservancy
Little Walnut Creek Conservancy District
Heritage Lake Conservancy District
Altra Indiana, LLC
Putnamville Correctional Facility

As the Steering Committee began to develop its mission statement and goals, the group began to refer to itself as the Big Walnut Creek Watershed Alliance (BWCWA). A formal identity will likely help the group grow and gain recognition in the community.

### 2.2 Mission Statement

The Big Walnut Creek Watershed Alliance is focused on improving water quality in the Big Walnut and Deer Creek areas by raising public awareness, protecting natural areas, enhancing adjacent landscapes, and allowing for the public use and enjoyment of the river.

## 2.3 Watershed Location

The Big Walnut Watershed is located in the west central portion of Indiana approximately 50 miles west from Indianapolis (Figures A, B). It encompasses 271,267 acres, or 424 square miles, of land across portions of five counties – Boone, Clay, Hendricks, Parke, and Putnam. The majority of the watershed is located within Putnam County. The Big Walnut Watershed is comprised of five smaller 11-digit watersheds. The watershed includes two major streams - Big Walnut Creek and Deer Creek. The headwaters of the watershed begin in Boone County, just south of Lebanon and flow southwesterly, through northwest Hendricks County and then on through Putnam County. Deer Creek flows into Mill Creek. Mill Creek continues westwardly where it meets with Big Walnut Creek and the Eel River begins here at the confluences of Big Walnut Creek and Mill Creek. US Highway 36 runs east-west through the central portion of the watershed, dividing it in half. Greencastle is the largest city located within the watershed area as it is the county seat of Putnam County. Other notable towns within the watershed include Jamestown, Lizton, North Salem, Bainbridge, Fillmore, and Cloverdale (Figure C).

## 2.4 Brief History of the Big Walnut Watershed

The Big Walnut Watershed has been studied for decades by several well-known biological scientists. Thomas Simon and Dr. James Gammon have researched the Big Walnut Creek to much extent. Their work has focused primarily on fish habitat and communities within the Big Walnut and Deer Creek Watersheds. Dr. Gammon's works on Big Walnut Creek date as far back as 1967.

Volunteer stream monitoring data is also available dating back to 2002. Several other scientists and conservation groups have expressed interest in protecting and managing Big Walnut watershed resources as well. Some of these scientists include staff from the Indiana Department of Natural Resources' Division of Nature Preserves (IDNR-DNP), The Nature Conservancy (TNC), and the Central Indiana Land Trust (CILTI). Several natural resource professionals concur that elements of the Big Walnut Watershed are unique, high quality, and regionally significant from an ecological perspective.

# 3.0 WATERSHED DESCRIPTION

## 3.1 Physical Setting

### 3.1.1 Topography

The Big Walnut Watershed encompasses approximately 271,267 acres, or 424 square miles, of land across portions of five counties – Boone, Clay, Hendricks, Parke, and Putnam. The majority of the watershed is located within Putnam County. This large watershed is located in all or portions of 17 USGS 7.5 minute quadrangles. The topography of the watershed ranges from flat rolling agricultural fields to undulating hills and valleys (Figure D). The Big Walnut Watershed is comprised of five smaller 11-digit watersheds, HUC numbers 05120203010, 05120203020, 05120203030, 05120203040, 05120203050.

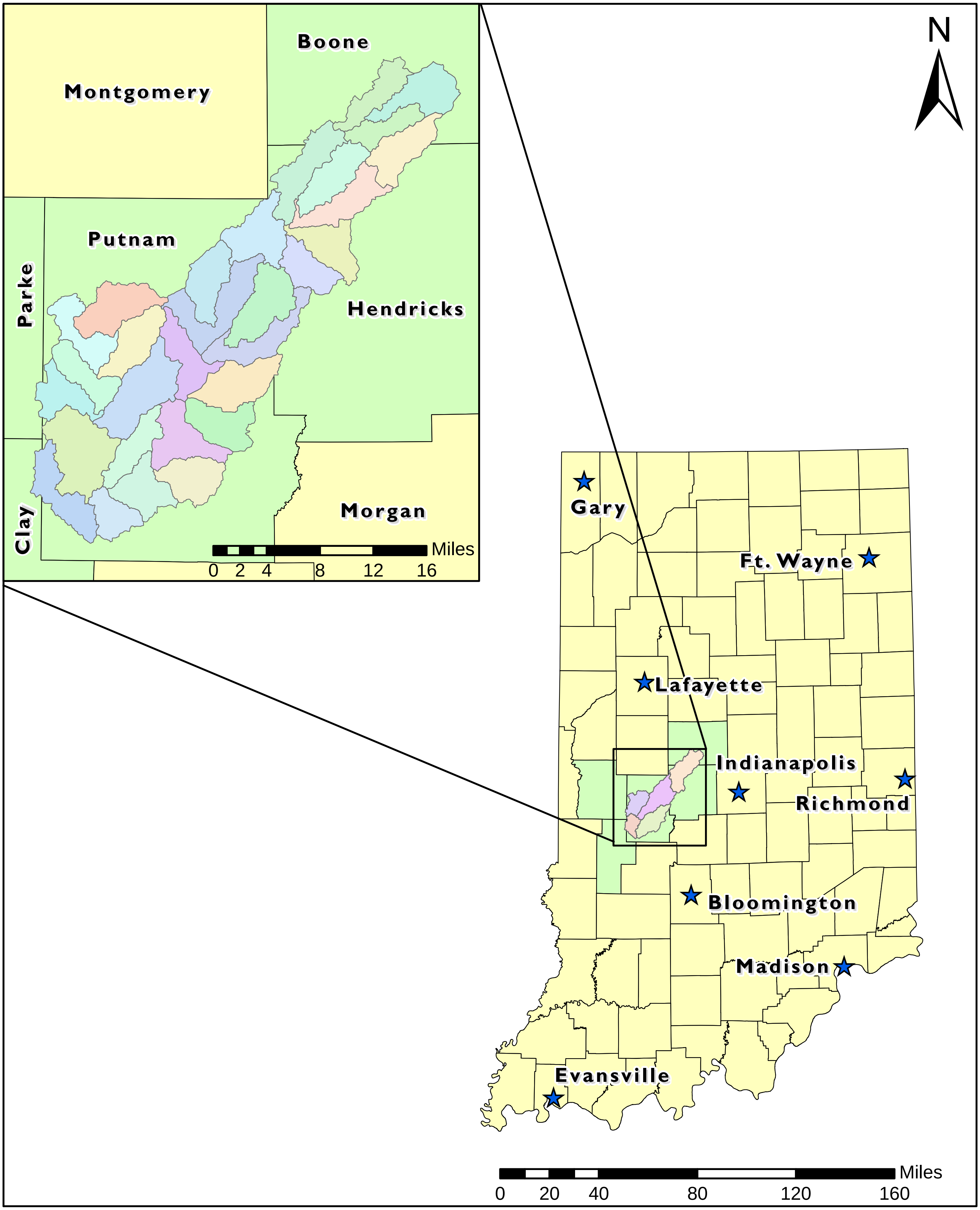



**Figure A - Watershed Location Map**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

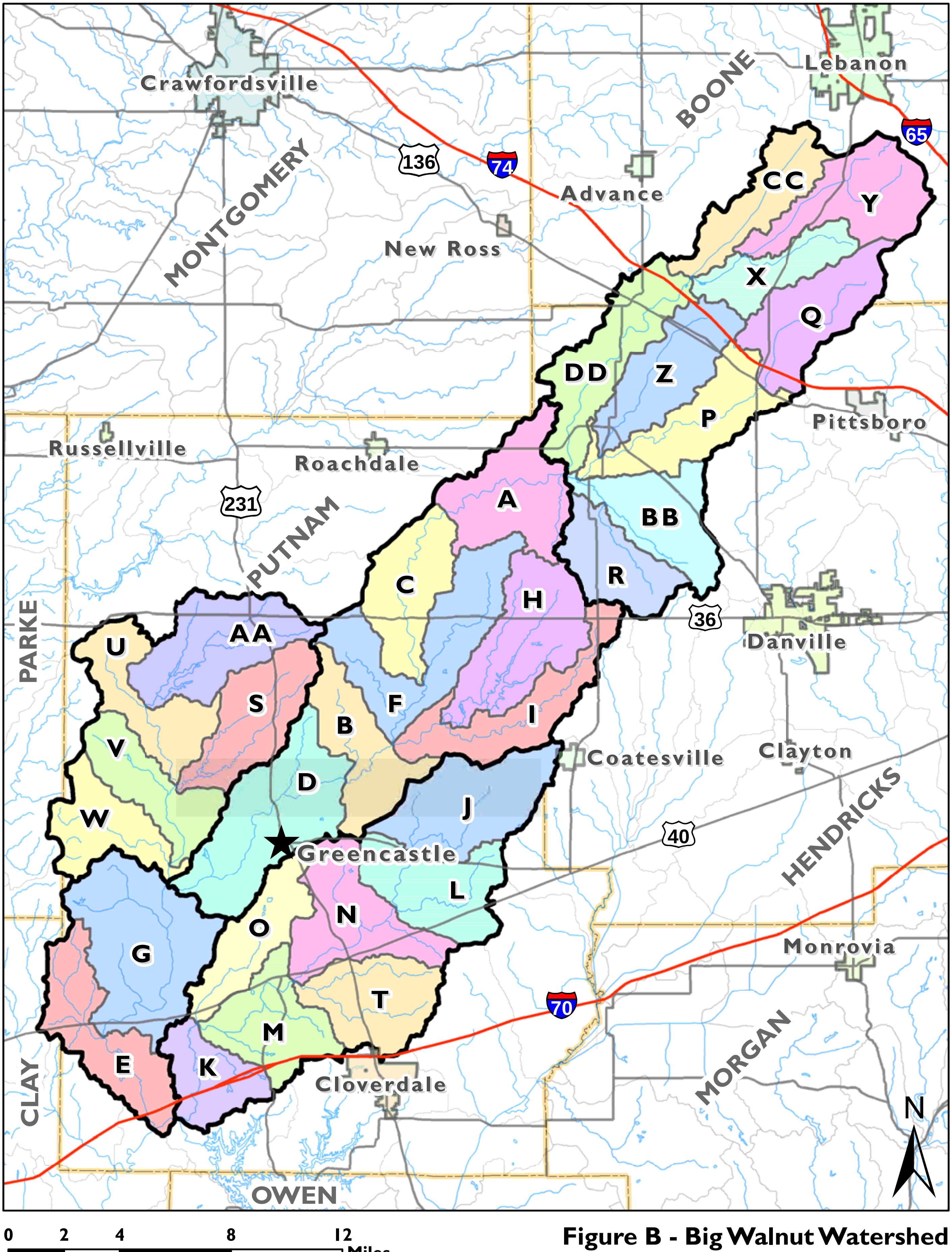



**Figure B - Big Walnut Watershed**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

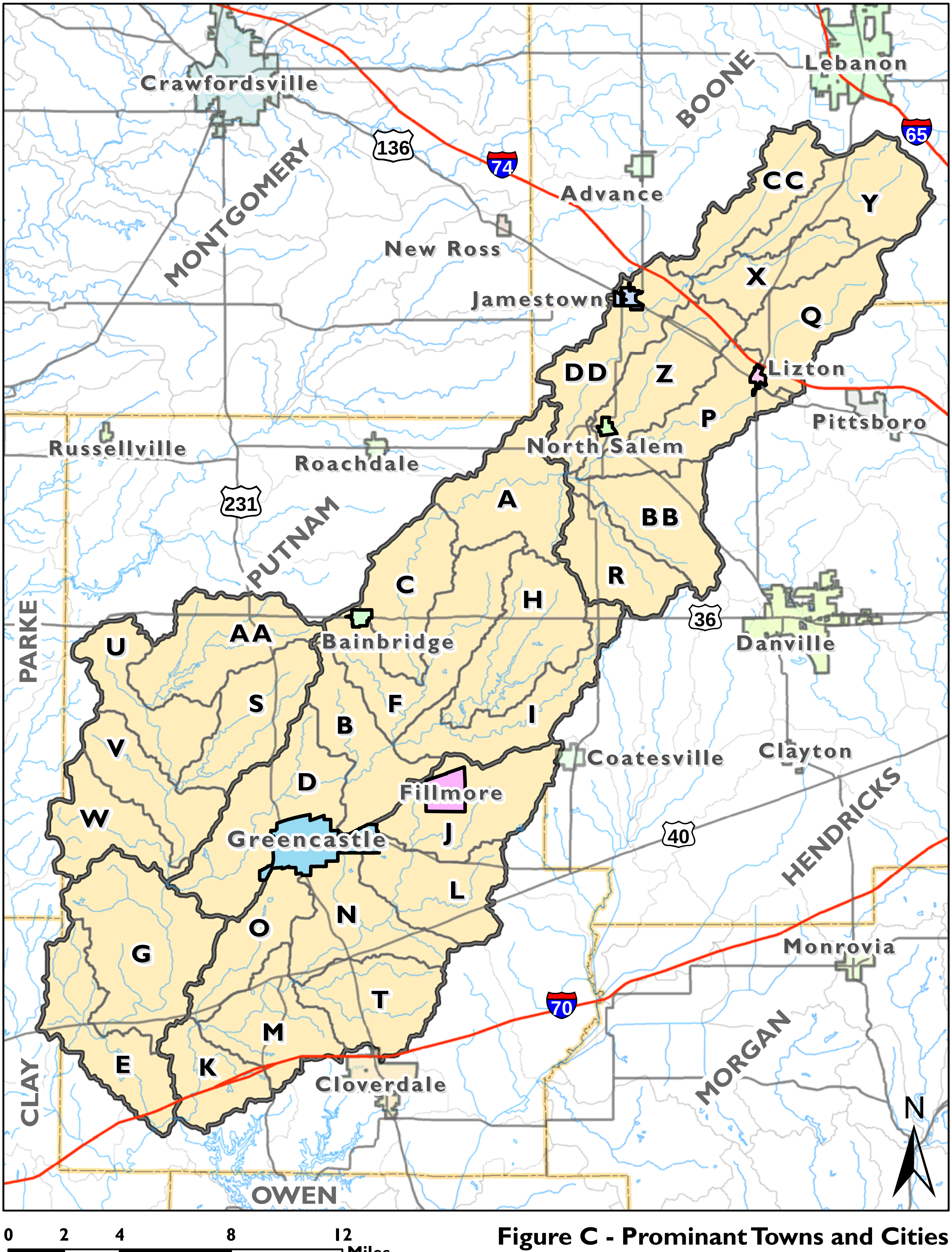



**Figure C - Prominant Towns and Cities**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

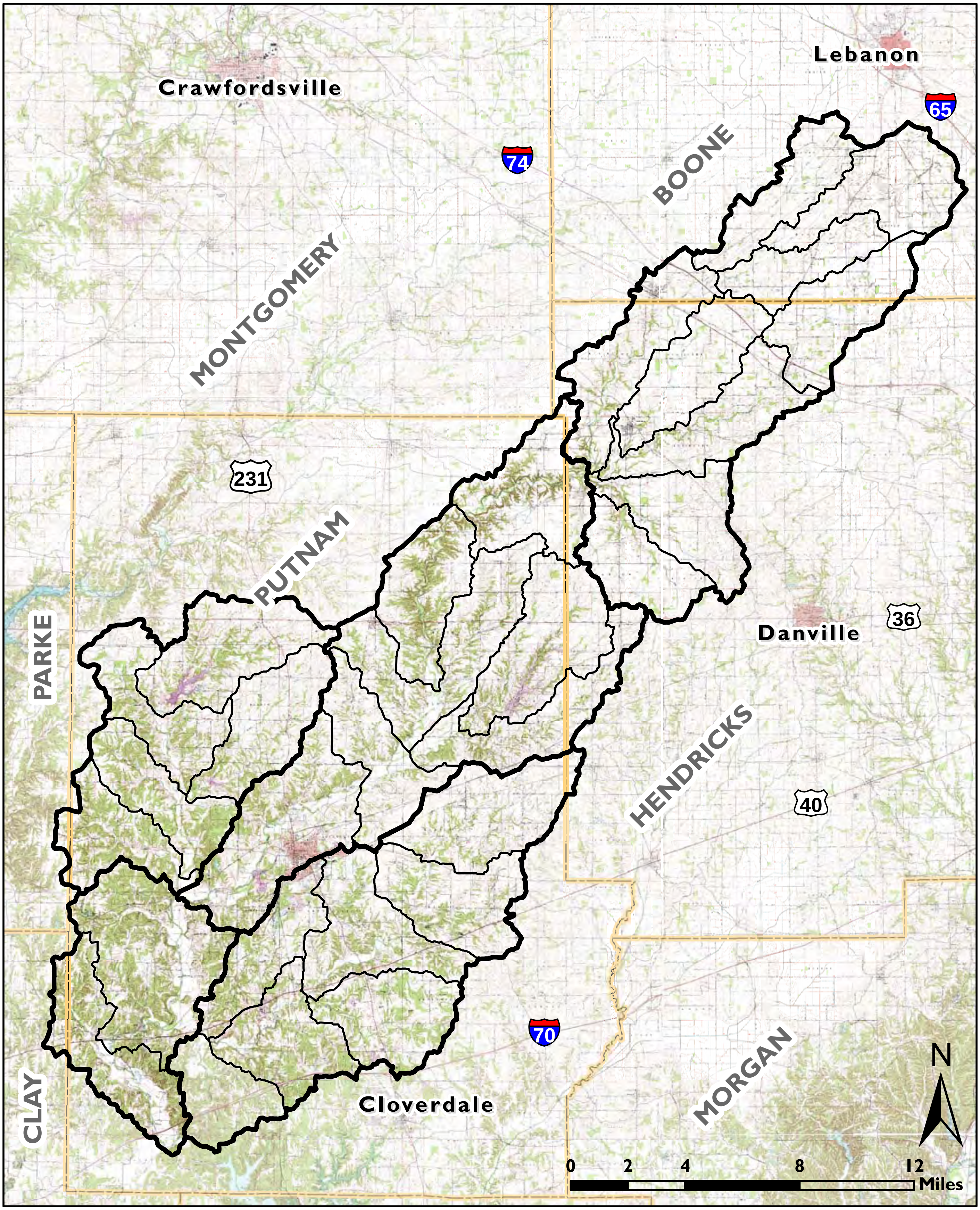



**Figure D - Topography**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

### 3.1.2 Hydrology

Streams

Big Walnut Creek begins in south central Boone County as the West Fork, Middle Fork, and East Forks of Big Walnut. These three streams merge together to form Big Walnut Creek southwest of North Salem in Hendricks County.

Deer Creek begins and ends within Putnam County. The headwaters of Deer Creek originate near Fillmore. The stream flows southwesterly past Putnamville to its confluence with Mill Creek.

In addition to Big Walnut and Deer Creeks, there are approximately 77 miles of perennial streams within the watershed (Figure E). The main stem of Big Walnut Creek is the longest stream within the watershed flowing approximately 19 miles and draining 212,740 acres (332 sq mi) of land. Deer Creek flows approximately 7 miles and drains 50,400 acres (79 sq mi) of land.

Lakes and Ponds

Many lakes are present within the watershed (Figure E). Most of the lakes were created by man-made impoundments out letting to surface waters. The lakes have been created for recreation, flood control, wildlife, and residential development. Ponds and lakes present special concern to the water quality within the watershed as they trap sediments, nutrients, and other contaminants.

Wetlands

In 1974 the U.S. Fish and Wildlife Service (USFWS) founded the National Wetland Inventory (NWI) as a way to provide information on the location, extent, and types of wetlands and deepwater habitats. Wetlands indicated on the maps were identified from aerial imagery based on visible vegetation, hydrology, and geology. The maps use the same grid as the USGS 7.5 minute topographic quadrangles.

Wetlands work to filter sediments and nutrients from run-off, store water; provide opportunity for groundwater recharge and discharge, and provide habitat for wildlife. These wetland functions often improve water quality and the biological health of nearby and downstream streams and lakes.

According to data from the NWI maps (Figures F1-F21, Appendix A), wetlands cover approximately 390 acres of land within the watershed (Table 1). Table 1 also summarizes the acres of wetland within each 14-HUC watershed based upon four classifications – forested, scrub-shrub, emergent, and open water.

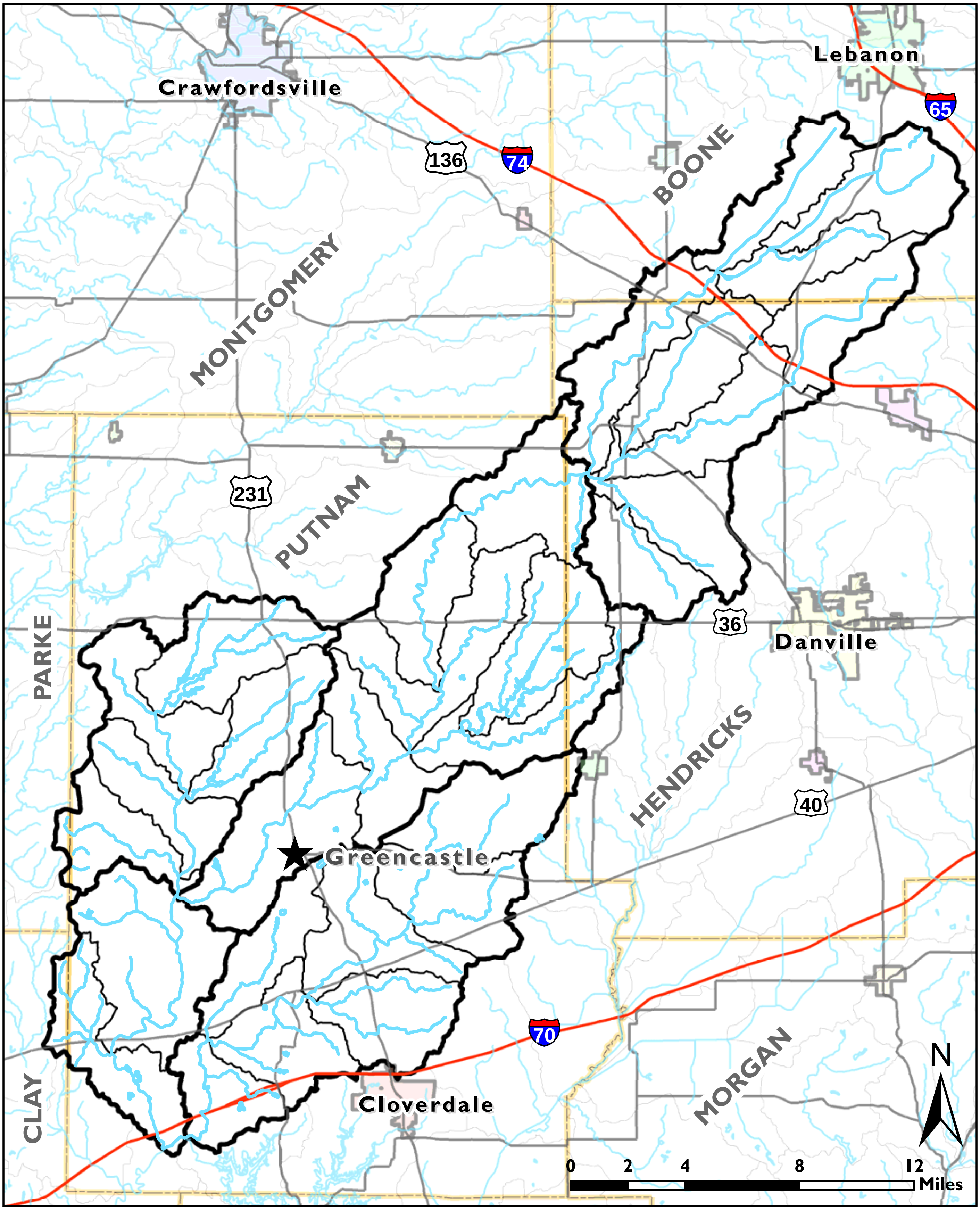



**Figure E - Lakes and Streams**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

| Table 1: NWI Wetland Acreages | | | | | | |
|---|---|---|---|---|---|---|
| | Wetland Type | Forested Acres | Scrub-Shrub Acres | Emergent Acres | Open Water Acres | Total Wetland Acres |
| A | Big Walnut Creek - Barnard | 9.00 | 0.00 | 0.16 | 6.86 | 16.02 |
| B | Big Walnut Creek - Dry Branch | 12.70 | 0.00 | 0.08 | 3.69 | 16.47 |
| C | Big Walnut Creek - Ernie Pyle Memorial Highway | 18.76 | 0.00 | 0.39 | 2.71 | 21.86 |
| D | Big Walnut Creek - Greencastle | 18.35 | 0.02 | 0.19 | 10.08 | 28.64 |
| E | Big Walnut Creek - Johnson Branch | 12.23 | 0.00 | 0.05 | 7.80 | 20.08 |
| F | Big Walnut Creek - Plum Creek/Bledsoe Branch | 11.04 | 0.11 | 0.09 | 2.95 | 14.19 |
| G | Big Walnut Creek - Snake Creek/Maiden Run | 17.14 | 0.22 | 0.06 | 7.89 | 25.31 |
| H | Clear Creek Headwaters (Putnam) | 3.64 | 0.33 | 0.30 | 37.21 | 41.48 |
| I | Clear Creek - Miller Creek | 9.83 | 0.01 | 0.10 | 1.79 | 11.73 |
| J | Deer Creek Headwaters (Putnam) | 3.63 | 0.00 | 0.30 | 4.33 | 8.26 |
| K | Deer Creek - Leatherwood Creek | 4.38 | 0.00 | 0.00 | 2.34 | 6.72 |
| L | Deer Creek - Little Deer Creek | 2.02 | 0.40 | 0.13 | 2.86 | 5.41 |
| M | Deer Creek - Mosquito Creek | 4.35 | 0.23 | 0.08 | 7.10 | 11.76 |
| N | Deer Creek - Owl Branch | 0.86 | 0.00 | 0.12 | 3.95 | 4.93 |
| O | Deweese Creek | 3.77 | 0.06 | 0.16 | 8.21 | 12.20 |
| P | East Fork Big Walnut Creek - Lower | 11.80 | 0.00 | 0.92 | 1.64 | 14.36 |
| Q | East Fork Big Walnut Creek - Ross Ditch | 4.20 | 0.00 | 0.21 | 0.43 | 4.84 |
| R | Hunt Creek | 4.64 | 0.10 | 0.70 | 0.77 | 6.21 |
| S | Jones Creek | 7.01 | 0.00 | 0.43 | 6.50 | 13.94 |
| T | Limestone Creek | 2.62 | 0.00 | 0.08 | 2.28 | 4.98 |
| U | Little Walnut Creek - Headwaters | 7.48 | 0.03 | 0.03 | 1.80 | 9.34 |
| V | Little Walnut Creek - Leatherman Creek | 7.75 | 0.21 | 0.07 | 1.82 | 9.85 |
| W | Little Walnut Creek - Long Branch | 1.58 | 0.00 | 0.00 | 1.18 | 2.76 |
| X | Main Edlin Ditch - Grassy Branch | 1.52 | 0.00 | 0.16 | 1.59 | 3.27 |
| Y | Main Edlin Ditch - Smith Ditch | 1.09 | 0.00 | 0.89 | 0.81 | 2.79 |
| Z | Middle Fork Big Walnut Creek | 7.60 | 0.13 | 0.69 | 1.11 | 9.53 |
| AA | Owl Creek | 3.67 | 0.00 | 1.73 | 33.69 | 39.09 |
| BB | Ramp Run - East Fork Outlet | 6.14 | 0.00 | 0.14 | 1.13 | 7.41 |
| CC | West Fork Big Walnut Creek Headwaters | 0.00 | 0.00 | 1.32 | 1.55 | 2.87 |
| DD | West Fork Big Walnut Creek - Lower | 9.35 | 0.13 | 1.33 | 2.09 | 12.90 |
| | Totals | 208.15 | 1.98 | 10.91 | 168.16 | 389.20 |

### 3.1.3 Soils

The Big Walnut Watershed consists of nearly level to gently sloping productive till plain. Most of the soils have a high water holding capacity. Figures G1-G5 (Appendix A) illustrates the location of hydric and upland soils within each 11-HUC watershed. Erosion can be of concern in areas with gentle slopes. The nearly level soils are usually wet in the spring holding free water within one foot of the surface.

The majority of the soils in the watershed are silt loams and silty clay loams. The major soil units include: Xenia silt loam (XeB2); Reelsville silt loam (ReA); Crosby silt loam (CrA or CudA); Treaty silty clay loam (ThrA); and Brookston silty clay loam (Bs).

The silt loams in this area are of the till plains landform with parent material of loess over loamy till. Their drainage ranges from somewhat poorly drained to moderately well drained with a water table of 6 inches to 24 inches. Silty clay loams are either of the till plains or glacial drainage channels landforms. The parent material is loess over loamy till. The drainage class of silty clay loams is poorly drained with a water table of 0 to 12 inches. Many of the silty clay loam soils are classified as hydric soils.

Table 2 summarizes the acres of hydric soil, percent hydric soil, acres of wetland, percent wetland, acres of floodplain, and percent floodplain for each 14-HUC watershed and for the entire Big Walnut Creek Watershed.

In addition to hydric soils, highly erodible land (HEL) was also researched. This information came from the NRCS, but is quite dated. The most current and official data is from 1987. According to this information, the majority of the soil types present within the watershed are considered highly erodible. Figures H1-H5 (Appendix A) illustrates the majority of HEL within the watershed on an 11-digit HUC.

The soils of the Big Walnut Creek Watershed were also researched for suitability for septic systems. The majority of the soils within the watershed have a very limited to somewhat limited rating on septic tank absorption fields and sewage lagoons. It is a common concern among the public and county agencies that many of the septic systems in the Big Walnut Creek Watershed are failing and contributing to water quality problems. However, if properly sited and maintained septic systems can be safe and effective for treating wastewater. Recommendations related to septic system maintenance and education will be addressed in future sections of this Plan.

### 3.1.4 Climate

Indiana is known regionally to have a climate with well-defined seasons. The location of the state within the continental US is the major factor in this seasonal cycle fluctuation. The Gulf of Mexico brings warm, moist air, while jet streams from Canada bring cold, polar air. Weather in Indiana changes every few days as the jet stream fluctuates bringing either cold polar air or warm tropical air.

Indiana's local climate varies statewide as it is influenced by differences in latitude, terrain, soils, and lakes. The Big Walnut Watershed's mean temperature between 1971 and 2000 ranged

| Table 2: Hydric Soils, NWI, & Floodplains | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Subwatershed | | Watershed Acreage | Acres of Hydric Soil | Percent Hydric Soil | Acres of NWI Wetlands | Percent NWI Wetlands | Acres of Floodplain | Percent Floodplain |
| A | Big Walnut Creek - Barnard | 10027 | 1830.47 | 18.26% | 16.02 | 0.16% | 1349.42 | 13.46% |
| B | Big Walnut Creek - Dry Branch | 8145 | 138.65 | 1.70% | 16.47 | 0.20% | 1577.54 | 19.37% |
| C | Big Walnut Creek - Ernie Pyle Memorial Highway | 8417 | 368.70 | 4.38% | 21.86 | 0.26% | 1874.25 | 22.27% |
| D | Big Walnut Creek - Greencastle | 14170 | 112.60 | 0.79% | 28.64 | 0.20% | 3599.22 | 25.40% |
| E | Big Walnut Creek - Johnson Branch | 9462 | 50.75 | 0.54% | 20.08 | 0.21% | 3070.40 | 32.45% |
| F | Big Walnut Creek - Plum Creek/Bledsoe Branch | 12122 | 393.92 | 3.25% | 14.19 | 0.12% | 2210.77 | 18.24% |
| G | Big Walnut Creek - Snake Creek/Maiden Run | 15537 | 185.30 | 1.19% | 25.31 | 0.16% | 4731.32 | 30.45% |
| H | Clear Creek Headwaters (Putnam) | 11125 | 1166.12 | 10.48% | 41.48 | 0.37% | 3043.60 | 27.36% |
| I | Clear Creek - Miller Creek | 8778 | 806.39 | 9.19% | 11.73 | 0.13% | 929.37 | 10.59% |
| J | Deer Creek Headwaters (Putnam) | 10573 | 710.52 | 6.72% | 8.26 | 0.08% | 450.90 | 4.26% |
| K | Deer Creek - Leatherwood Creek | 5852 | 21.43 | 0.37% | 6.72 | 0.11% | 1464.85 | 25.03% |
| L | Deer Creek - Little Deer Creek | 8798 | 372.65 | 4.24% | 5.41 | 0.06% | 1453.22 | 16.52% |
| M | Deer Creek - Mosquito Creek | 8094 | 17.56 | 0.22% | 11.76 | 0.15% | 2188.67 | 27.04% |
| N | Deer Creek - Owl Branch | 9727 | 93.07 | 0.96% | 4.93 | 0.05% | 2640.76 | 27.15% |
| O | Deweese Creek | 7006 | 109.63 | 1.56% | 12.20 | 0.17% | 1956.26 | 27.92% |
| P | East Fork Big Walnut Creek - Lower | 8909 | 2213.82 | 24.85% | 14.36 | 0.16% | 1866.64 | 20.95% |
| Q | East Fork Big Walnut Creek - Ross Ditch | 8975 | 6594.90 | 73.48% | 4.84 | 0.05% | 0.00 | 0.00% |
| R | Hunt Creek | 6880 | 1780.79 | 25.88% | 6.21 | 0.09% | 564.39 | 8.20% |
| S | Jones Creek | 8704 | 323.68 | 3.72% | 13.94 | 0.16% | 1740.03 | 19.99% |
| T | Limestone Creek | 8366 | 35.52 | 0.42% | 4.98 | 0.06% | 2831.42 | 33.84% |
| U | Little Walnut Creek - Headwaters | 7780 | 476.40 | 6.12% | 9.34 | 0.12% | 1888.78 | 24.28% |
| V | Little Walnut Creek - Leatherman Creek | 7303 | 134.30 | 1.84% | 9.85 | 0.13% | 2026.52 | 27.75% |
| W | Little Walnut Creek - Long Branch | 6991 | 183.47 | 2.62% | 2.76 | 0.04% | 1159.35 | 16.58% |
| X | Main Edlin Ditch - Grassy Branch | 5622 | 5441.71 | 96.79% | 3.27 | 0.06% | 2349.50 | 41.79% |
| Y | Main Edlin Ditch - Smith Ditch | 9377 | 9282.08 | 98.99% | 2.79 | 0.03% | 1586.98 | 16.92% |

| Table 2: Hydric Soils, NWI, & Floodplains (cont) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Subwatershed | | Watershed Acreage | Acres of Hydric Soil | Percent Hydric Soil | Acres of NWI Wetlands | Percent NWI Wetlands | Acres of Floodplain | Percent Floodplain |
| Z | Middle Fork Big Walnut Creek | 8681 | 2831.21 | 32.61% | 9.53 | 0.11% | 1634.87 | 18.83% |
| AA | Owl Creek | 10343 | 315.98 | 3.06% | 39.09 | 0.38% | 1610.67 | 15.57% |
| BB | Ramp Run - East Fork Outlet | 8219 | 1748.68 | 21.28% | 7.41 | 0.09% | 977.04 | 11.89% |
| CC | West Fork Big Walnut Creek Headwaters | 7065 | 6958.16 | 98.49% | 2.87 | 0.04% | 1120.43 | 15.86% |
| DD | West Fork Big Walnut Creek - Lower | 10107 | 3559.23 | 35.22% | 12.90 | 0.13% | 2966.18 | 29.35% |
| | Totals | 271155 | 48257.69 | 17.80% | 389.20 | 0.14% | 56863.35 | 20.97% |

from a low of 17.7°F in January to a high of 86.6°F in July, with the average low at 25.9°F and the average high at 75.5°F. Precipitation in the area from 1971 to 2000 ranges from a minimum of 2.40 inches to a maximum of 5.41inches during any one month, with an annual average of 44.20 inches.

The frost free growing season in Indiana varies from 150 days in northeastern Indiana to over 200 days in southwestern Indiana. From 1971 to 2000, the Greencastle/Putnam County area averages 184 days at a base temperature of 32°F. The last spring frost usually occurs on April 21 and the first fall frost usually occurs on October 20. Appendix B includes available historical growing season, precipitation, and temperature data.

### 3.1.5 Natural History

The Big Walnut Watershed lies within three ecoregions as designated by the Environmental Protection Agency (EPA) (Figure I). The regions are the Eastern Corn Belt Plains (55), the Interior Plateau (71); and the Interior River Lowland (72).

<u>EASTERN CORN BELT PLAINS</u>

The Eastern Corn Belt Plains is comprised of rolling till plains with local end moraines. Soils are rich, loamy, and well drained. Extensive glacial deposits of the Wisconsinan age are present. Native vegetation was mostly beech forests with elm-ash swamp forests present in wetter areas. Corn, soybean, and livestock production predominate as today's land use.

<u>INTERIOR PLATEAU</u>

The Interior Plateau is characterized by landforms of open hills, irregular plains, and tablelands composed of limestone, chert, sandstone, siltstone, and shale. Native vegetation was primarily oak-hickory forests with some bluestem prairie areas. Land use today consists of mostly forest with some cropland.

<u>INTERIOR RIVER VALLEYS AND HILLS</u>

The Interior River Lowland is characterized by forested valley slopes, wide and flat bottomed valleys, and glacial till plains. Native vegetation consisted of oak-hickory forests and swamp forests were common in the lowlands. Land use today is a mix of cropland, forests, and surface coal mining.

### 3.1.6 Endangered Species and Significant Natural Areas

The Indiana Department of Natural Resources (IDNR) Division of Nature Preserves maintains the Indiana Natural Heritage Data Center database. This database keeps track of Indiana's endangered, threatened, or rare (ETR) species and high quality natural communities. Development of the database allowed for documentation of significant species and areas and management priorities for areas where these special species or habitats are present.

<u>ETR Species</u>

A number ETR species and natural areas are present within the Big Walnut Watershed. Since the Big Walnut Watershed is so large, the number of ETR species is numerous. Lists of the ETR species by county have been included as Appendix C. State and federal classification guidelines are listed below.

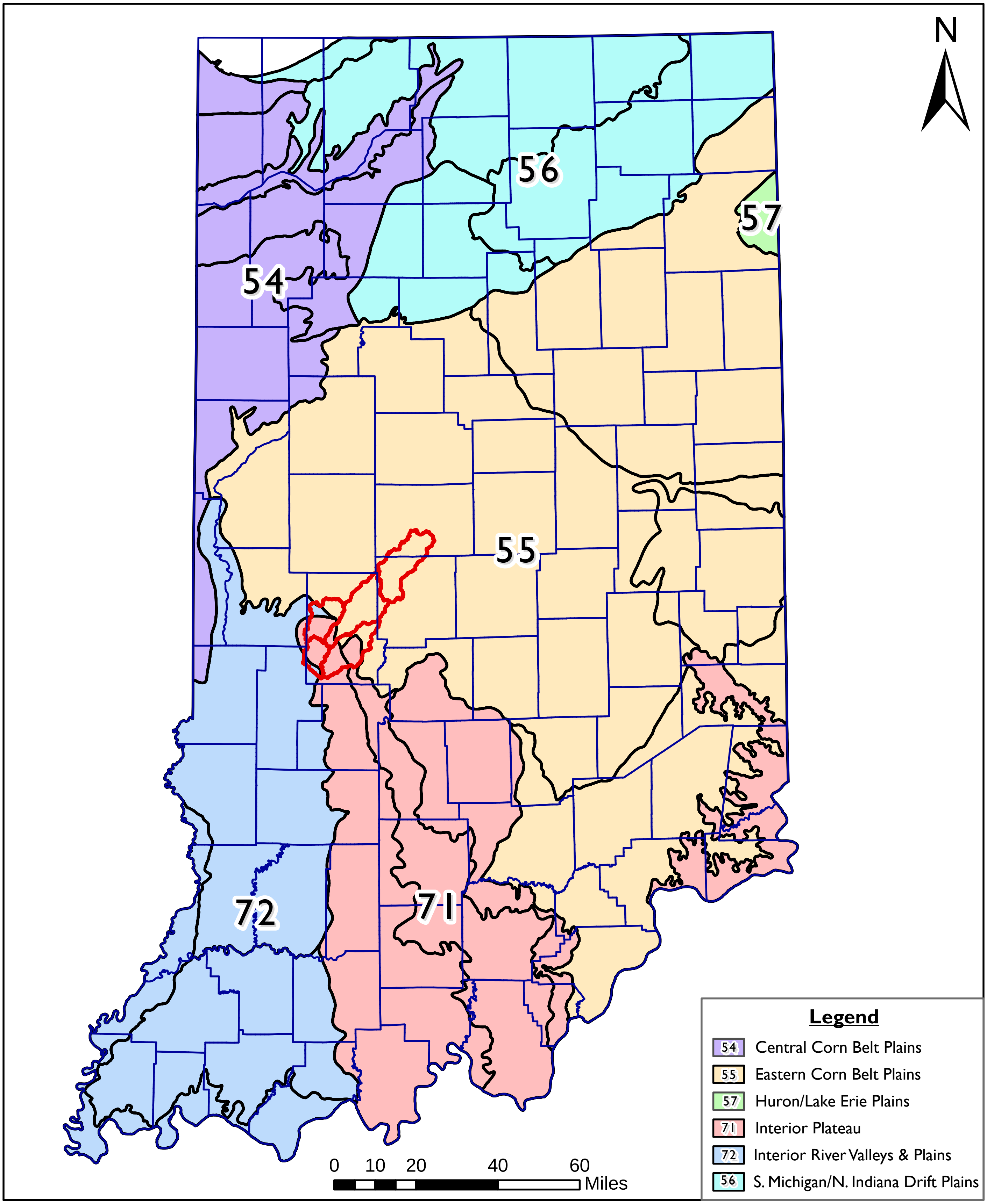



**Figure 1 - Ecoregions**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

STATE

Endangered: Any species whose chances of survival within the state are in jeopardy and are in danger of disappearing from the state. Species listed as endangered by the federal government and occur in Indiana are included on this list.

Rare: A species is rare if it is common nowhere. This generally means that the species has very specific habitat requirements and that the habitat itself is rare. A species can also be rare if populations can survive in niches outside the area that is considered to be common.

Special Concern: Any species with known or suspected concern of limited abundance or distribution in Indiana.

FEDERAL

Endangered: Any species in danger of becoming extinct throughout all or part of its range.

Threatened: Any species likely to become endangered in the near future throughout all or part of its range.

All counties within the Big Walnut Watershed are listed within the range of the federally endangered Indiana bat (*Myostis sodalis*). The bald eagle (*Haliaeetus leucocephalus*) was recently delisted.

Significant Natural Areas

Several significant natural areas are present within the Big Walnut Watershed (Figures J1-J5, Appendix A). These areas are maintained, preserved, and protected by a number of different organizations including IDNR, The Nature Conservancy (TNC), and the Central Indiana Land Trust Incorporated (CILTI).

Table 3 identifies natural areas located within the Big Walnut Watershed, the county of location, and the organization that maintains and/or manages them.

**Table 3: Natural Areas**

| **Natural Area** | **Location** | **Organization** |
|---|---|---|
| Big Walnut Nature Preserve | Putnam County | TNC, IDNR |
| Fern Cliff Nature Preserve | Putnam County | TNC |
| Hall Woods Nature Preserve | Putnam County | IDNR |
| Hemlock Ridge Nature Preserve | Putnam County | CILTI |
| McCloud Nature Park | Hendricks County | Hendricks County Parks |

Big Walnut Nature Preserve consists of approximately 2700 acres along Big Walnut Creek in northeastern Putnam County. It was designated a National Natural Landmark in 1985 and is known for its rolling hills and steep ravines.

Fern Cliff Nature Preserve is a 157 acre preserve in western Putnam County. The preserve was dedicated as a National Natural Landmark in 1980. It's a popular sanctuary in Indiana known for its steep, forested cliff and ravines. The ferns found in Fern Cliff Nature Preserve provide an abundance of unique vegetation.

Hall Woods Nature Preserve is another preserve located along Big Walnut Creek just east of Bainbridge. It is approximately 90 acres and has a high frequency of large white oak trees present. Other species present include sassafras, buckeye, maple, dogwood, beech, tulip trees, and many others.

Hemlock Ridge Nature Preserve is approximately 40 acres in the Big Walnut Creek Corridor. It is named for its stands of Canadian or Eastern Hemlock (*Tsuga canandensis*) present along the bedrock bluffs. The preserve also has two notable ravines which lead to a breath-taking view of Big Walnut Creek. Hemlock Ridge is also home to two State Rare plant species: Longstalk Sedge (*Carex pedunculata*) and Wolf Bluegrass (*Poa wolfii*).

McCloud Nature Park is a 232 acre park located in northwestern Hendricks County. The park is open to the public and offers numerous activities and programs throughout the year. It also provides access to Big Walnut Creek for those wishing to take a canoe or kayak trip.

The IDNR Division of Nature Preserves has drafted a corridor habitat protection plan for the Big Walnut Creek Corridor to continue the protection of key lands such as the ones mentioned above and others nearby that are currently publically managed lands. Figure K represents lands that are currently being managed and those that are priorities to be protected.

## 3.2 Built Environment

### 3.2.1 Cities and Towns

Several towns and one city are located in the Big Walnut Watershed. The City of Greencastle, located at the intersection of US 231 and IN 240, is the largest population center in the watershed and is the county seat of Putnam County. Greencastle was founded in 1821 by Ephraim Dukes and is believed to have been named after Greencastle, Pennsylvania. Greencastle is also home to DePauw University.

Other notable towns located in the watershed include: Jamestown, Lizton, North Salem, and Bainbridge. Coatesville and Cloverdale are right on the boundary of the watershed, but the majority of the towns do not lie within the watershed. Many other unincorporated towns are also located within the watershed. These are shown on Figure L and include: Milledgeville, New Brunswick, Barnard, New Maysville, New Winchester, Groveland, Clinton Falls, Brick Chapel, Cary, Fillmore, Fox Ridge, Limedale, Mount Meridian, Westland, Putnamville, Cradick Corner, Jenkinsville, Pleasant Gardens, Reelsville, Brunerstown, Keytsville, and Manhattan.

### 3.2.2 Population

Increases in population lead to decreases in the availability of land and resources for agricultural and natural resource uses. The Big Walnut Watershed is located in a predominately rural area. The watershed is mostly located in Putnam County, which ranks 43$^{rd}$ in population out of the 92 Indiana counties. Greencastle, Bainbridge, and Fillmore combine for a total population based

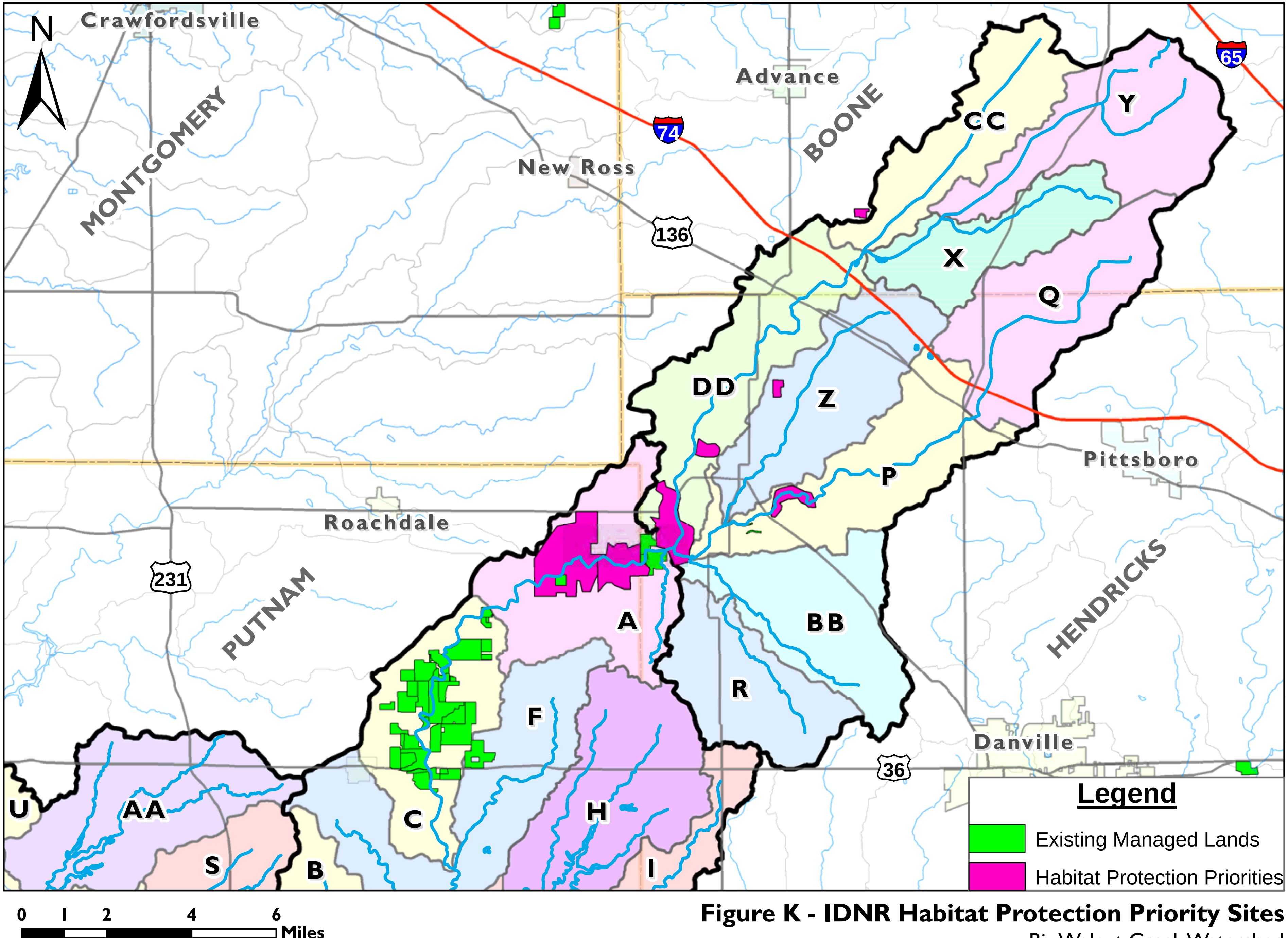



**Figure K - IDNR Habitat Protection Priority Sites**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

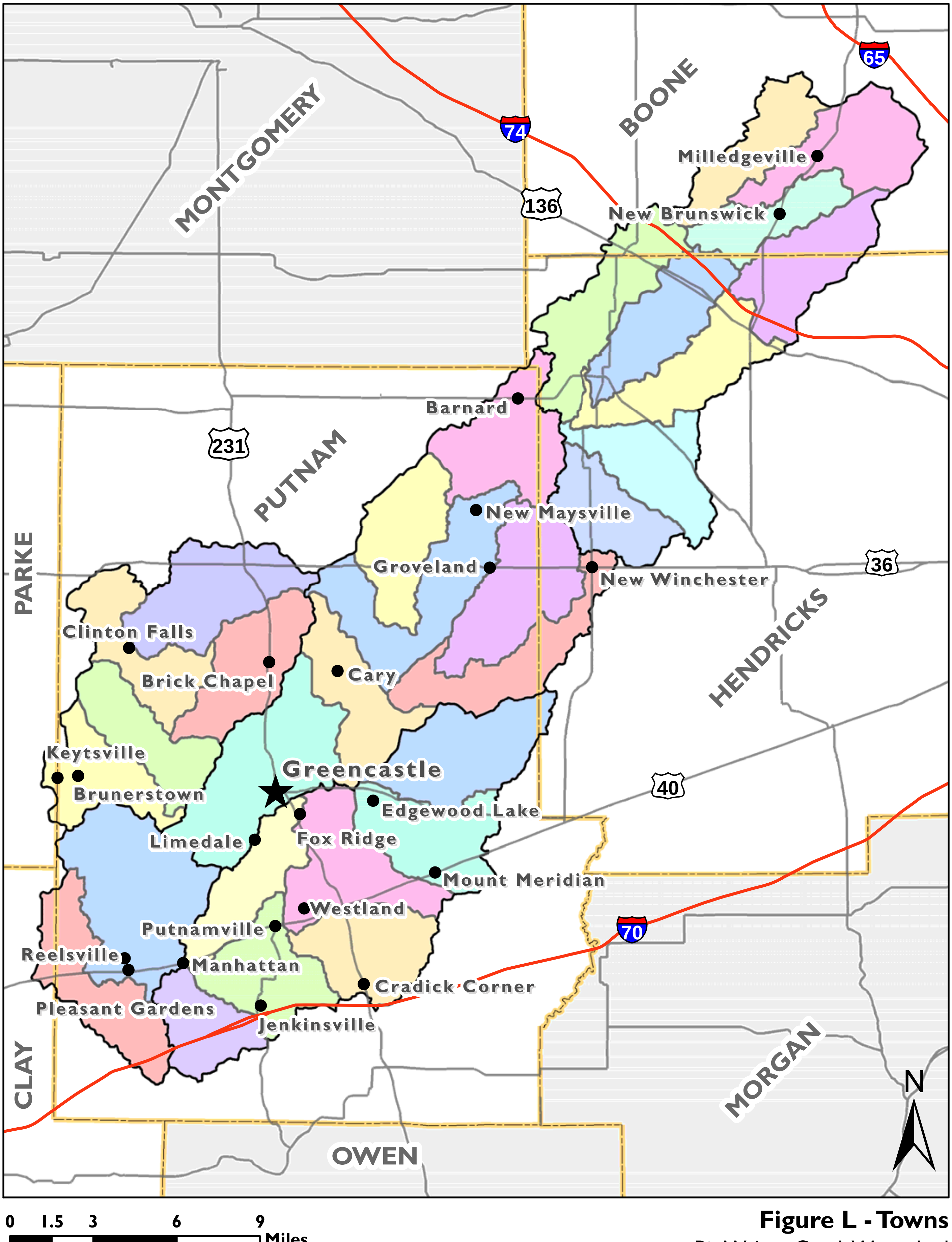



**Figure L - Towns**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

on July 2005 estimates of 11,415 persons. The population for these three towns according to the April 2000 Census was 11,168 persons. The area showed a population change of 3.29 percent from April 2000 to July 2005.

Some of the other towns that contribute to the population of the watershed include Jamestown with 957 persons, Lizton with 358 persons, and North Salem with 636 persons for a total of 1951 persons. The April 2000 Census showed the combined population of these three towns to be 1849 persons with a change of 3.95 percent from April 2000 to July 2005. As shown by Census data, no one area of the watershed is developing or growing faster than any other. Population growth rates are steady and comparable across the watershed.

However regardless of the rate of population increase, the given population number and/or density of a given area often creates carries additional regulator complexity in regard to land use and utility planning. Due to the population densities that define Greencastle and DePauw University, both communities are considered Municipal Separate Storm Sewer entities (MS4s) and as such, have advanced stormwater management requirements. Similarly, Greencastle is also governed by more municipal ordinances than other population centers in the watershed.

### 3.2.3 Municipal Separate Storm Sewer Systems (MS4s)

Under NPDES Phase II stormwater regulations, several communities, universities, or other entities with concentrated populations were required to begin managing stormwater and reducing urban pollutant loads. These entities are referred to as Municipal Separate Storm Sewer Systems, or more commonly called MS4s. The name relates to the concept of understanding and managing stormwater influences from storm sewers that are not part of combine storm sewer systems. This sort of storm sewer infrastructure and associated outfalls to local streams is widespread geographically and often quite diverse in engineering design. Official MS4 entities are required to address six Minimum Control Measures (MCMs) in their effort to improve water quality:

1. Public Education Outreach
2. Public Involvement
3. Illicit Discharge Detection & Elimination
4. Construction Site Stormwater Runoff Control
5. Post-Construction Site Stormwater Runoff Control
6. Pollution Prevention & Good Housekeeping

There are two localized MS4 entities in the Big Walnut watershed, Greencastle and DePauw University. Boone and Hendricks Counties have other MS4 entities within their respective counties, but these areas are not within the Big Walnut Creek Watershed. Greencastle and DePauw are combined entities for the purposes of MS4 permitting and therefore work together to address the required Minimum Control Measures outlined in the Phase II regulation. This MS4's boundary is shown in Figures M1-M2. Known stormwater outfalls within the Greencastle/DePauw MS4 are also shown in this figure.

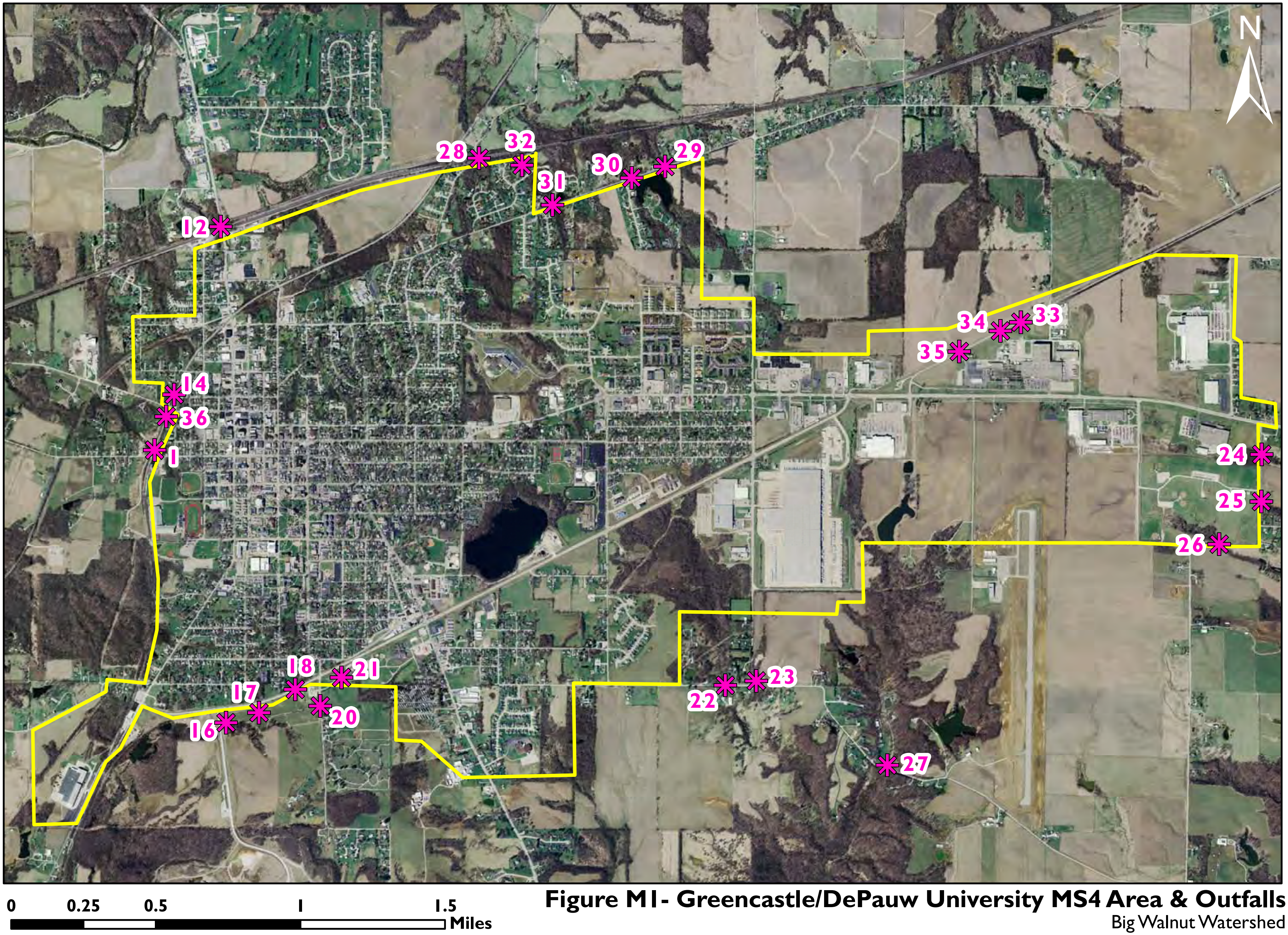



**Figure M1- Greencastle/DePauw University MS4 Area & Outfalls**

Big Walnut Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

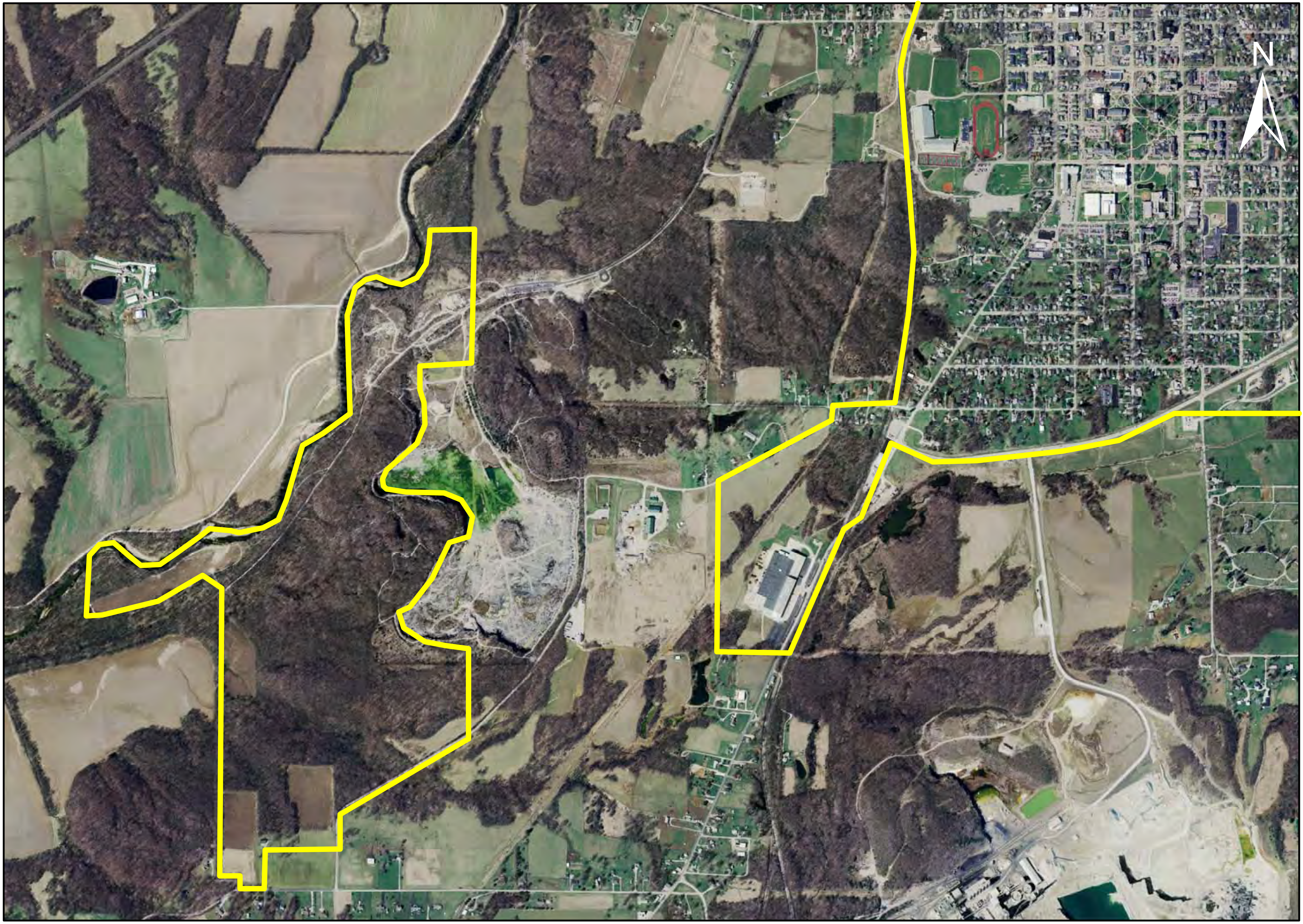



**Figure M2- Greencastle/DePauw University MS4 Area & Outfalls**

Big Walnut Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

BOONE COUNTY

The Boone County Surveyor has taken on the responsibility of managing the Phase II Stormwater Program within the unincorporated portion of the County. Primary Contact information is:

Kenny Hedge
County Surveyor
116 West Washington Street
Lebanon, IN 46052
765-483-4444
khedge@co.boone.in.us

HENDRICKS COUNTY

There are six official MS4 entities in the Hendricks County. These include Avon, Brownsburg, Danville, Pittsboro, Plainfield, and the remaining unincorporated areas in the county. The Hendricks County Surveyor's Office has implemented a program that includes many of the State mandated MS4 requirements as an official MS4. Currently, the program includes the enforcement of a storm water and sediment control ordinance, mapping of stormwater inlets, and educational signage at stormwater inlets. All inlets, outlets, and drains are being built into the county GIS.

Primary Contact for the unincorporated areas of Hendricks County is:
Clean Water Department
355 S. Washington St., #214
Danville, IN 46122
phone 317-718-6068
fax 317-718-6105

Primary contact for MSC 1 and 2 is:
Brooke Moore, Education Coordinator for Hendricks County
Hendricks County Partnership for Water Quality
195 Meadow Drive, Suite 1
Danville, IN 46122
317-718-6130
bmoore@co.hendricks.in.us

PUTNAM COUNTY

The Greencastle Planning Office has implemented the program that includes many of the State mandated MS4 requirements as an official MS4 for the city of Greencastle and DePauw University. Currently, the program includes the enforcement of a storm water and sediment control ordinance, mapping of stormwater inlets, and educational signage at stormwater inlets.

Primary contact for the MS4 program is:

Shannon Norman
City of Greencastle Planner
1 North Locust Street
PO Box 607
Greencastle, IN 46135
765-653-7719
snorman@cityofgreencastle.com

### 3.2.4 Recreational Areas

Recreational areas can be found throughout the Big Walnut Watershed (Figures J1-J5, Appendix A). These include such areas as city or county parks, golf courses, or water/motor sport activities. Greencastle and Putnam County are home to the majority of these features within the watershed. The county is home to two golf courses, two motor sport racetracks, a minimum of four recreational parks, a trail system, and a number of lakes. Jamestown, located in Boone County is also home to Tomahawk Hills Golf Course. Finally, McCloud Nature Park is located in North Salem, in Hendricks County.

### 3.2.5 Historic Structures

There are 15 structures located in the Big Walnut Watershed that are listed on the National Register of Historic Places and/or the State Register of Historic Places. One is located in Boone County and 14 in Putnam County. Table 4 indicates the historic feature, its location, historic significance, and period of significance. Historic features are an important part to the fabric of many rural counties. Their presence may limit or dictate surrounding land use and has the potential to impact the type of projects that may be undertaken in certain areas due to their status as protected resources.

## 4.0 EXISTING ENVIRONMENTAL CONDITIONS

### 4.1 State – 303d List

A search of the Indiana Department of Environmental Management (IDEM) Section 303(d) List of Impaired Waters for 2006 revealed that 29 segments of stream within the Big Walnut Watershed are listed (Figure N, see Appendix D for complete list by segment). Of the 29 listed, all but two are listed for *E. coli.* These two are listed for impaired biotic communities; one is listed as an impaired biotic community as well as *E. coli.* Seven streams are listed for fish consumption advisory (FCA) for Mercury.

Recent approval of the 2008 Section 303(d) List of Impaired Waters also lists 29 segments of stream within the Big Walnut Watershed. Of the 29 listed, all but two are listed for *E. coli.* These two are listed for impaired biotic communities; one is listed as an impaired biotic community as well as *E. coli.* Two streams are listed for fish consumption advisory (FCA) for Mercury.

### 4.2 Research Conducted by Dr. James Gammon

Dr. James Gammon, professor emeritus of Biological Sciences at DePauw University, has conducted much research on Big Walnut Creek. His work, focused primarily on fish

**Table 4: Historic Places**

| Historic Place | Historic Place (Other Names) | Location | Historic Significance | Period of Significance |
|---|---|---|---|---|
| Andrew B. VanHuys Round Barn | Kincaid Barn | Boone County | Architecture/Engineering; Event | 1900-1949 |
| Appleyard | Alexander C. Stevenson Farm; Ballard Farm | Putnam County | Person | 1825-1899 |
| The Boulders | James Orville Cammack and Adelene Buston House | Putnam County | Architecture/Engineering | 1900-1949 |
| Brick Chapel United Methodist Church | Montgomery Chapel | Putnam County | Event | 1825-1974 |
| Courthouse Square Historic District | Courthouse Square District | Putnam County | Architecture/Engineering; Event | 1800-1949 |
| Delta Kappa Epsilon Fraternity House | | Putnam County | Event; Architecture/Engineering | 1925-1949 |
| East College of DePauw University | East College of Indiana Asbury University | Putnam County | Event; Architecture/Engineering | 1850-1899 |
| Alfred Hirt House | | Putnam County | Architecture/Engineering; Person | 1875-1949 |
| McKim Observatory, DePauw University | | Putnam County | Event; Architecture/Engineering | 1875-1899 |
| F.P. Nelson House | | Putnam County | Architecture/Engineering | 1850-1874 |
| James Edington Montgomery O'Hair House | J.E.M. O'Hair House | Putnam County | Architecture/Engineering | 1825-1899 |
| Putnam County Bridge No. 159 | Reelsville Bridge | Putnam County | Architecture/Engineering; Event | 1925-1949 |
| Putnamville Presbyterian Church | Putnamville Methodist Church; Putnamville United Methodist Church | Putnam County | Architecture/Engineering; Event | 1825-1849 |
| Lycurgus Stoner House | Edna Brown House | Putnam County | Architecture/Engineering | 1875-1899 |
| William C. VanArsdel House | The Elms | Putnam County | Architecture/Engineering | 1900-1924 |

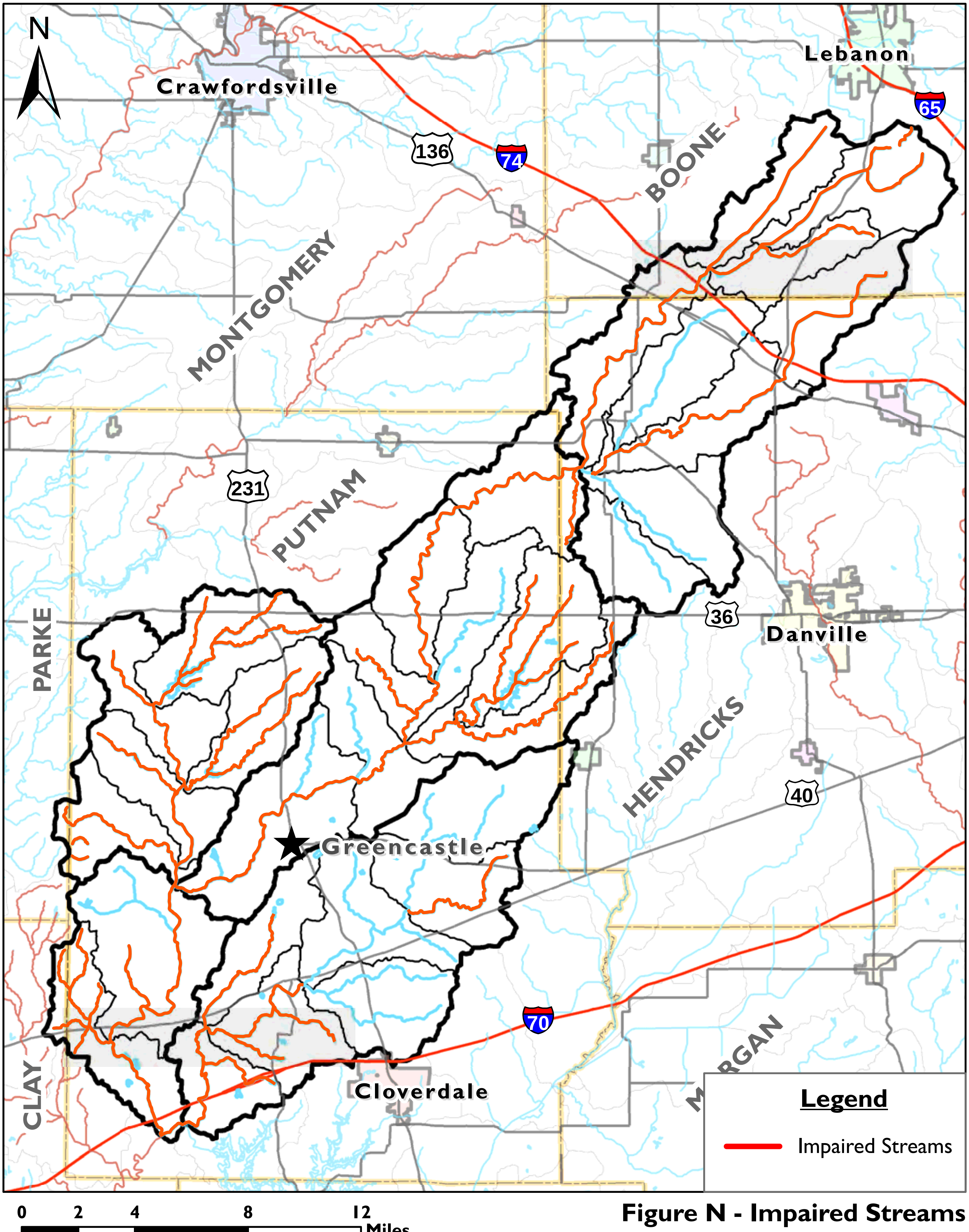



**Figure N - Impaired Streams**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

assemblages, but also including macroinvertebrates and aquatic plants, dates back to the late 1960's. He continued assessments and analyses into the late 1990's. His work during the 1990's in the Big Walnut Creek Watershed led to the assessment of critical areas within the watershed (compilation of several references used, see References Section). Dr. Gammon's observations and assessments were summarized and geographically interpreted by authors of this plan. Critical areas identified by summarizing Dr. Gammon's work were based solely on fish IBIs (Index of Biotic Integrity). This analysis was made in order to render subwatershed conclusions for comparative purposes to current subwatershed conditions/critical areas, as well as to aid in restoration prioritization (Figure O). This illustration shows the most critical areas (subwatersheds) in red, moderate areas in yellow, and low priority areas in green.

Two of the three identified critical areas are located in Boone County at the headwaters of Big Walnut Creek. This area is known to be largely agricultural. The third critical area is located in the area of Deer Creek in Putnam County. This area is also largely agricultural and is home to several confined animal feeding operations.

## 4.3 Regulated Environmental Issues

A search of IDEM's Office of Land Quality records located areas/sites within the Big Walnut Watershed that could pose a threat to the environment and are therefore regulated entities. The search revealed the following regulated environmental issues within the watershed: Permitted Solid Waste – 1, Brownfields – 1, Confined Feeding Operations (CFO) – 27, Open Dumps – 2, National Pollutant Discharge Elimination System (NPDES) Pipes – 17, Waste Septage Sites – 3, Leaking Underground Storage Tanks (LUST) – 32. Figures P1-P5 (Appendix A) present these findings and the locations of the environmental issues.

## 4.4 Additional Regulated Entity Information

Further research was conducted on NPDES dischargers (noted above). The Environmental Protection Agency's (EPA) Envirofacts Warehouse and Enforcement and Compliance History Online (ECHO) give listings of dischargers by county. There are 21 listed dischargers in the Big Walnut Watershed. Half of these NPDES dischargers are for sewerage systems or water supplies. The remainders of the permits are for industries or schools. These NPDES sites and a summary of their recent compliance records are shown in Figure Q and are listed in Table 5. This analysis provides important perspective when interpreting current water quality data in upcoming sections of this plan. Regular non-compliance of some NPDES dischargers could result in elevated concentrations of pollutants that may otherwise be attributed to non-point sources of pollution, including those being investigated and targeted as part of this plan.

The Indiana Department of Natural Resources (IDNR) Division of Water maintains a database of Significant Water Withdrawal Facilities (SWWF). This database lists all facilities that withdrawal significant amounts of ground and surface water. The database has information from 2004 to 2006. There are 14 facilities with the Big Walnut Creek Watershed that are listed as SWWFs. Of these 14 facilities, four are of notable interest, pumping over 100,000 gallons of water annually. Figure R maps the location of these facilities. Table 6 lists the facilities with corresponding numbers to the map locations, along with water source, well depth, annual pumping, and other additional information. Consideration of these facilities aids in understanding demands and pressures on groundwater supplies and base flows in Big Walnut

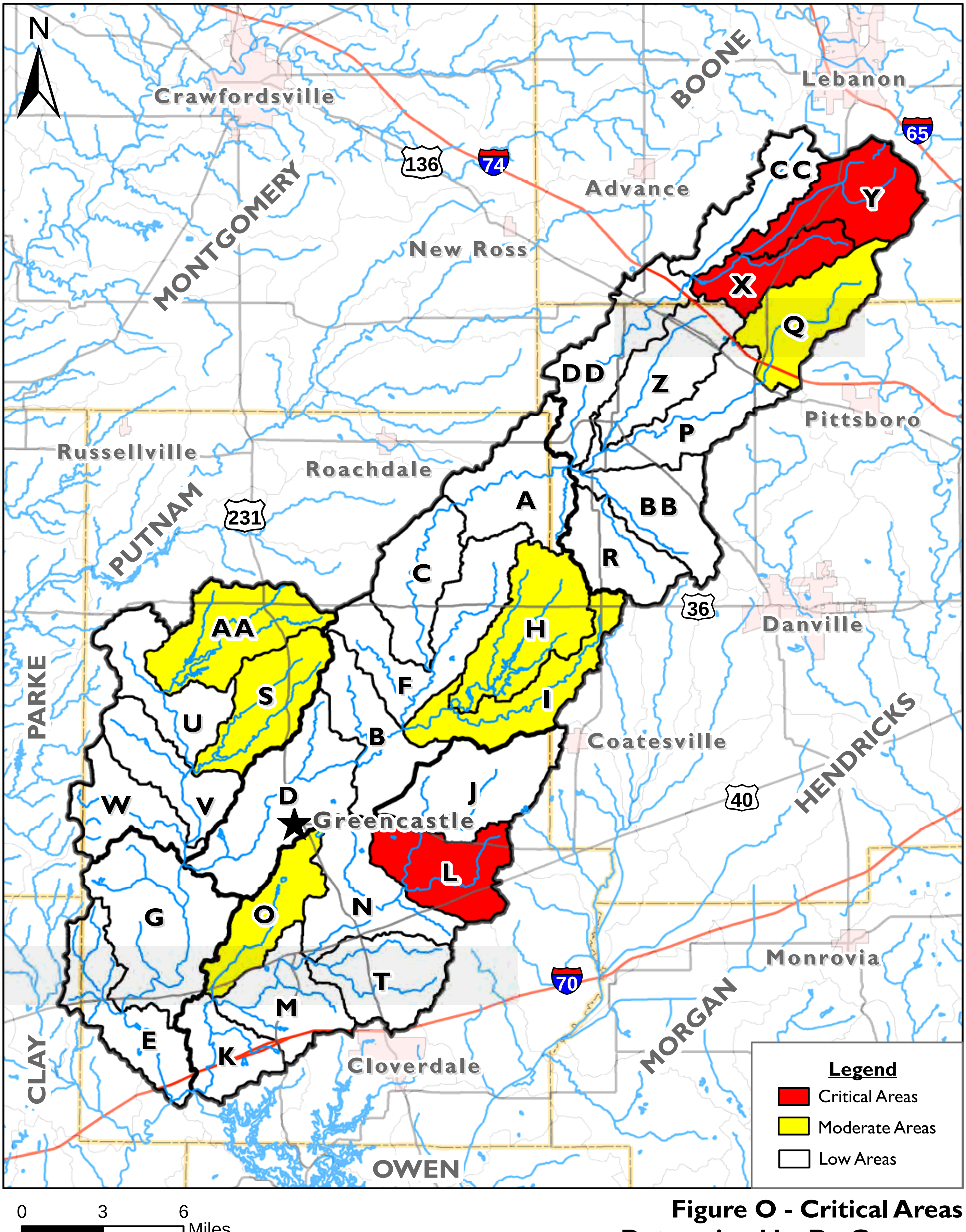



**Figure O - Critical Areas Determined by Dr. Gammon**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

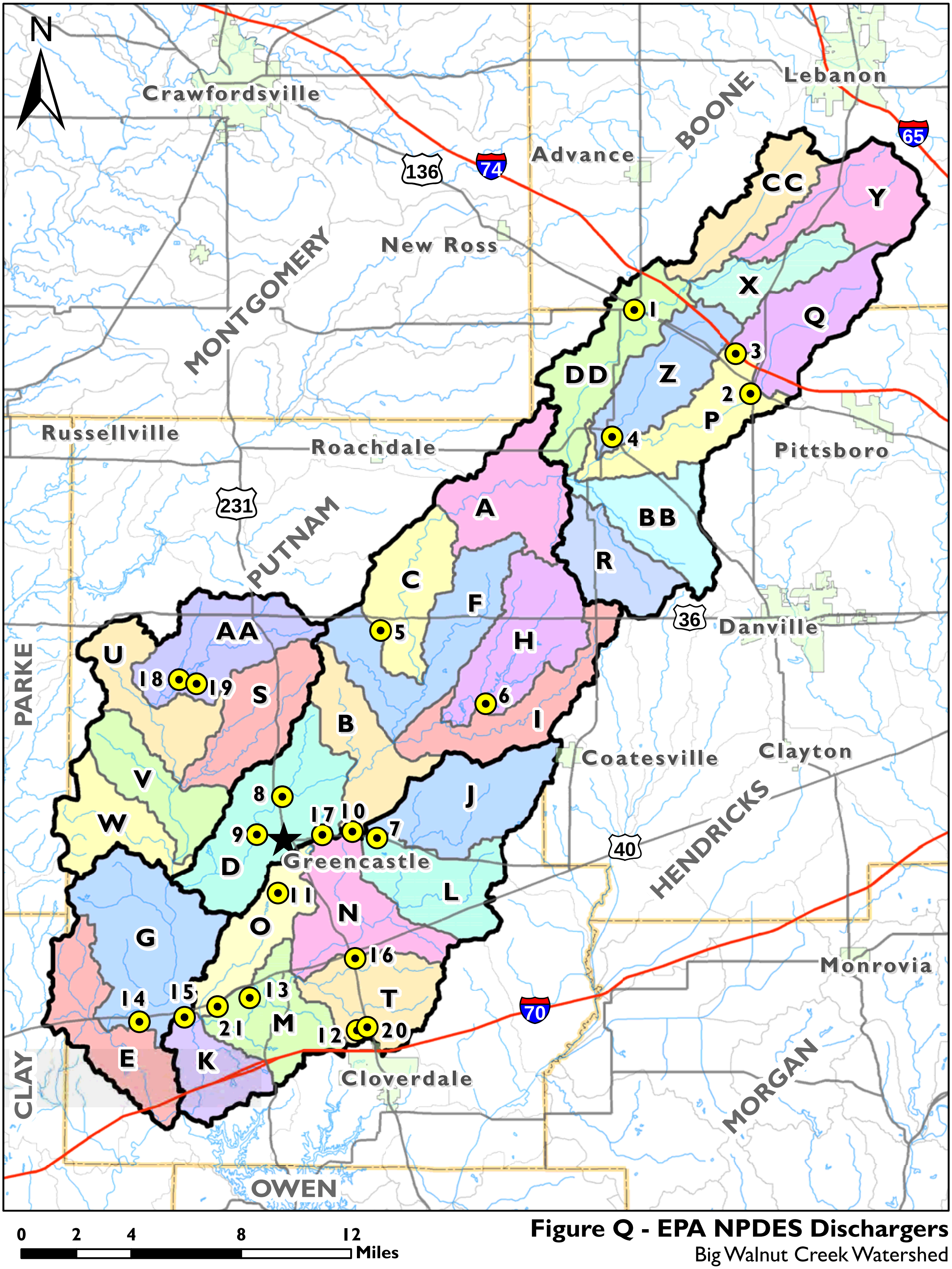



**Figure Q - EPA NPDES Dischargers**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

**Table 5: NPDES Dischargers**

| Site | Discharger | NPDES Discharge Category | County | Quarters of Non-Compliance (out of 12 qtrs- current as of Oct-Dec 07) | Violation |
|---|---|---|---|---|---|
| 1 | Jamestown WWTP | Sewerage System | Boone | 3 | Chlorine, Nitrogen, DO, TSS |
| 2 | Lizton Municipal STP | Sewerage System | Hendricks | 10 | Nitrogen, E. coli, TSS |
| 3 | Lizton Rest Areas I-74 | Regulation & Administration of Transportation Systems | Hendricks | n/a | n/a |
| 4 | North Salem WWTP | Sewerage System | Hendricks | 1 | TSS |
| 5 | Bainbridge Municipal WWTP | Sewerage System | Putnam | 8 | pH, BOD |
| 6 | Clear Creek Conservancy District | Sewerage System | Putnam | 3 | Nitrogen, E. coli, TSS |
| 7 | Crown Point Equipment Corporation | Motor Vehicle Parts and Accessories | Putnam | n/a | n/a |
| 8 | Greencastle Department of Water | Water Supply | Putnam | 7 | n/a |
| 9 | Greencastle Municipal STP | Sewerage System | Putnam | 8 | Nitrogen |
| 10 | IBM (Int'l Business Machines) Corporation | Die Cut Paper - Paperboard and Cardboard | Putnam | 0 | |
| 11 | Lone Star Industries Landfill | Cement, Hydraulic | Putnam | 7 | TSS |
| 12 | Martin Marietta Cloverdale 524 | Crushed and Broken Limestone | Putnam | 2 | TSS |
| 13 | Putnamville Correctional Facility | Correctional Institutions | Putnam | 5 | pH, BOD, E. coli, TSS |
| 14 | Reelsville Elementary School | Elementary and Secondary Schools | Putnam | 10 | missed schedule, BOD |
| 15 | Reelsville Water Treatment Plant | Water Supply | Putnam | n/a | n/a |
| 16 | South Putnam High School | Elementary and Secondary Schools | Putnam | 8 | BOD, TSS |
| 17 | United (Speedway) 6022 | Gasoline Service Station | Putnam | n/a | n/a |
| 18 | Van Bibber Lake Conservancy District | Sewerage System | Putnam | 4 | Missed Schedule |
| 19 | Van Bibber Water Treatment Plant | Water Supply | Putnam | 4 | pH, E. coli |
| 20 | Altra Indiana, LLC | | Putnam | n/a | n/a |
| 21 | Buzzi Unicem - Manhattan Shale Mine | | Putnam | n/a | n/a |

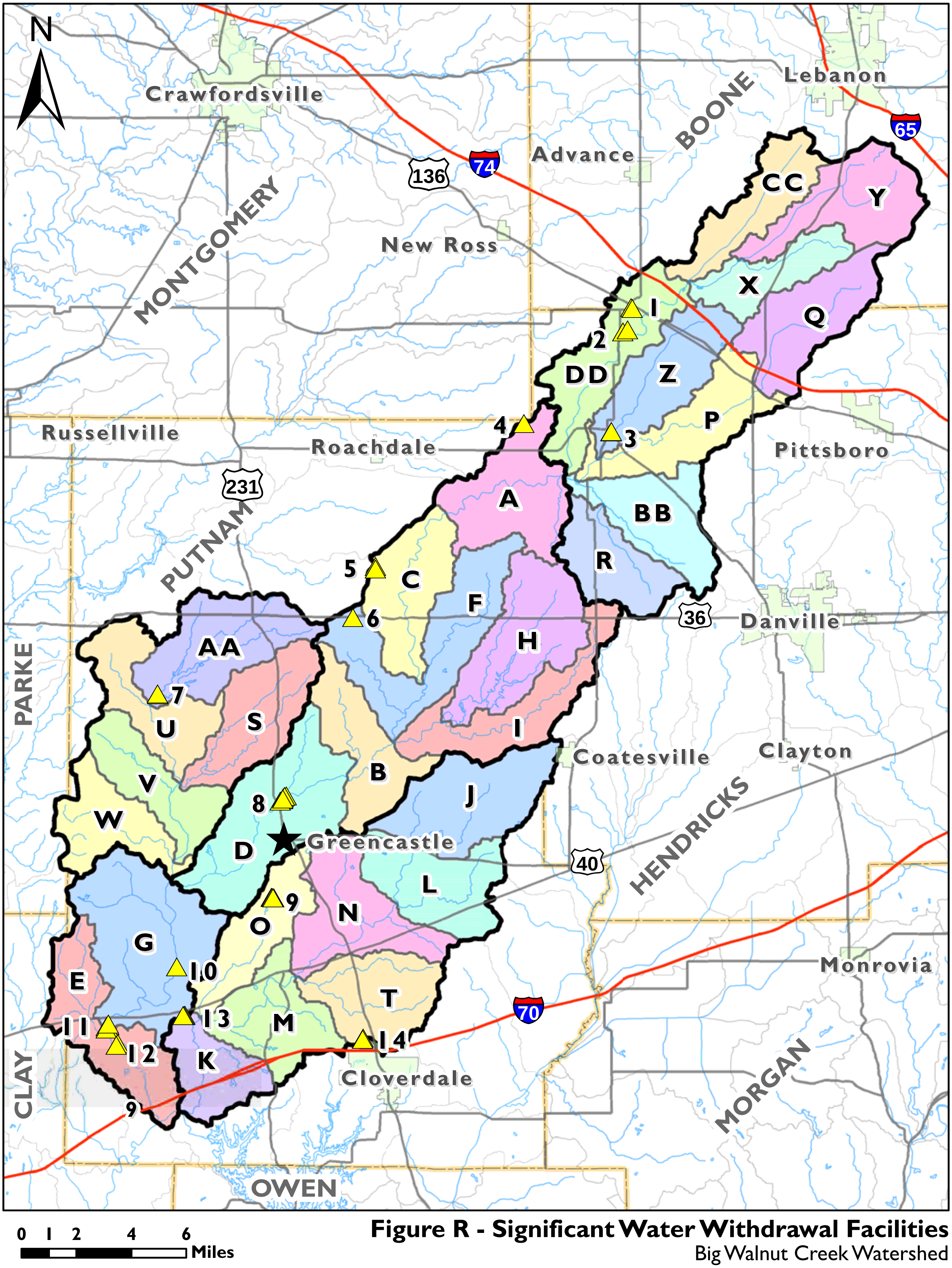



**Figure R - Significant Water Withdrawal Facilities**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

Table 6: Significant Water Withdrawal Facilities

| SITE | USER | CATEGORY | SOURCE | DEPTH (FEET) | AQUIFER/WATER SOURCE | PUMPING CAPACITY (GPM) | YEAR | PUMPED ANNUALLY |
|---|---|---|---|---|---|---|---|---|
| 1 | Jamestown Mun Water Works | Public Supply | WELL | 31 | Sand and Gravel | 40 | 2004 | 0 |
| 1 | Jamestown Mun Water Works | Public Supply | WELL | 31 | Sand and Gravel | 40 | 2005 | 0 |
| 1 | Jamestown Mun Water Works | Public Supply | WELL | 31 | Sand and Gravel | 40 | 2006 | 0 |
| 1 | Jamestown Mun Water Works | Public Supply | WELL | 63 | Sand and Gravel | 30 | 2004 | 0 |
| 1 | Jamestown Mun Water Works | Public Supply | WELL | 64 | Sand and Gravel | 30 | 2005 | 0 |
| 1 | Jamestown Mun Water Works | Public Supply | WELL | 65 | Sand and Gravel | 30 | 2006 | 0 |
| 2 | Tomahawk Hills GC | Irrigation | INTAKE | | Unknown Lake | 300 | 2004 | 3957 |
| 2 | Tomahawk Hills GC | Irrigation | WELL | 160 | Sand and Gravel | 10 | 2004 | 0 |
| 2 | Tomahawk Hills GC | Irrigation | INTAKE | | Unknown Lake | 300 | 2004 | 3957 |
| 2 | Tomahawk Hills GC | Irrigation | WELL | 160 | Sand and Gravel | 10 | 2004 | 0 |
| 2 | Tomahawk Hills GC | Irrigation | INTAKE | | Unknown Lake | 300 | 2004 | 3957 |
| 2 | Tomahawk Hills GC | Irrigation | WELL | 160 | Sand and Gravel | 10 | 2004 | 0 |
| 3 | North Salem Water Corp | Public Supply | WELL | 100 | Sand and Gravel | 100 | 2004 | 8345 |
| 3 | North Salem Water Corp | Public Supply | WELL | 96 | Sand and Gravel | 150 | 2004 | 8338 |
| 3 | North Salem Water Corp | Public Supply | WELL | 100 | Sand and Gravel | 100 | 2004 | 8345 |
| 3 | North Salem Water Corp | Public Supply | WELL | 96 | Sand and Gravel | 150 | 2004 | 8338 |
| 3 | North Salem Water Corp | Public Supply | WELL | 100 | Sand and Gravel | 100 | 2004 | 8345 |
| 3 | North Salem Water Corp | Public Supply | WELL | 96 | Sand and Gravel | 150 | 2004 | 8338 |
| 4 | Britton Farms | Irrigation | WELL | 240 | Sand and Gravel | 1100 | 2004 | 0 |
| 4 | Britton Farms | Irrigation | WELL | 240 | Sand and Gravel | 1100 | 2005 | 0 |
| 4 | Britton Farms | Irrigation | WELL | 240 | Sand and Gravel | 1100 | 2006 | 0 |
| 5 | North Putnam School Corp | Public Supply | WELL | 298 | Sand and Gravel | 110 | 2004 | 4176 |
| 5 | North Putnam School Corp | Public Supply | WELL | 298 | Sand and Gravel | 110 | 2005 | 4110 |

| Table 6: Significant Water Withdrawal Facilities (cont) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **SITE** | **USER** | **CATEGORY** | **SOURCE** | **DEPTH (FEET)** | **AQUIFER/WATER SOURCE** | **PUMPING CAPACITY (GPM)** | **YEAR** | **PUMPED ANNUALLY** |
| 5 | North Putnam School Corp | Public Supply | WELL | 298 | Sand and Gravel | 110 | 2006 | 3619 |
| 5 | North Putnam School Corp | Public Supply | WELL | 290 | Unknown | 110 | 2004 | 0 |
| 5 | North Putnam School Corp | Public Supply | WELL | 290 | Unknown | 110 | 2005 | 0 |
| 5 | North Putnam School Corp | Public Supply | WELL | 290 | Unknown | 110 | 2006 | 0 |
| 6 | Town of Bainbridge | Public Supply | WELL | 159 | Limestone | 100 | 2004 | 7737 |
| 6 | Town of Bainbridge | Public Supply | WELL | 159 | Limestone | 100 | 2005 | 12850 |
| 6 | Town of Bainbridge | Public Supply | WELL | 159 | Limestone | 100 | 2006 | 11300 |
| 7 | Van Bibber Lake Conservancy | Public Supply | WELL | 43 | Sand and Gravel | 100 | 2004 | 0 |
| 7 | Van Bibber Lake Conservancy | Public Supply | WELL | 43 | Sand and Gravel | 100 | 2005 | 0 |
| 7 | Van Bibber Lake Conservancy | Public Supply | WELL | 43 | Sand and Gravel | 100 | 2006 | 0 |
| 7 | Van Bibber Lake Conservancy | Public Supply | WELL | 46 | Sand and Gravel | 100 | 2004 | 24274 |
| 7 | Van Bibber Lake Conservancy | Public Supply | WELL | 46 | Sand and Gravel | 100 | 2005 | 24274 |
| 7 | Van Bibber Lake Conservancy | Public Supply | WELL | 46 | Sand and Gravel | 100 | 2006 | 24274 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 54 | Sand and Gravel | 1000 | 2004 | 666800 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 54 | Sand and Gravel | 1000 | 2005 | 666800 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 54 | Sand and Gravel | 1000 | 2006 | 666800 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 55 | Sand and Gravel | 200 | 2004 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 55 | Sand and Gravel | 200 | 2005 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 55 | Sand and Gravel | 200 | 2006 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 54 | Sand and Gravel | 600 | 2004 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 54 | Sand and Gravel | 600 | 2005 | 0 |

| Table 6: Significant Water Withdrawal Facilities (cont) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **SITE** | **USER** | **CATEGORY** | **SOURCE** | **DEPTH (FEET)** | **AQUIFER/WATER SOURCE** | **PUMPING CAPACITY (GPM)** | **YEAR** | **PUMPED ANNUALLY** |
| 8 | Greencastle Water Dept | Public Supply | WELL | 54 | Sand and Gravel | 600 | 2006 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 49 | Sand and Gravel | 1000 | 2004 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 49 | Sand and Gravel | 1000 | 2005 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 49 | Sand and Gravel | 1000 | 2006 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 55 | Sand and Gravel | 1000 | 2004 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 55 | Sand and Gravel | 1000 | 2005 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 55 | Sand and Gravel | 1000 | 2006 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 48 | Sand and Gravel | 650 | 2004 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 48 | Sand and Gravel | 650 | 2005 | 0 |
| 8 | Greencastle Water Dept | Public Supply | WELL | 48 | Sand and Gravel | 650 | 2006 | 0 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2004 | 400 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2005 | 400 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2006 | 400 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2004 | 64700 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2005 | 64400 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2006 | 63600 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2004 | 65100 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2005 | 64500 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2006 | 63700 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2004 | 65540 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2005 | 65600 |
| 9 | Lone Star Industries | Industry | INTAKE | | Unnamed Quarry | 850 | 2006 | 63400 |
| 10 | Oakalla Valley Partnership | Irrigation | INTAKE | | Big Walnut Creek | 350 | 2004 | 0 |
| 10 | Oakalla Valley Partnership | Irrigation | INTAKE | | Big Walnut Creek | 350 | 2005 | 0 |
| 10 | Oakalla Valley Partnership | Irrigation | INTAKE | | Big Walnut Creek | 350 | 2006 | 0 |

| Table 6: Significant Water Withdrawal Facilities (cont) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **SITE** | **USER** | **CATEGORY** | **SOURCE** | **DEPTH (FEET)** | **AQUIFER/WATER SOURCE** | **PUMPING CAPACITY (GPM)** | **YEAR** | **PUMPED ANNUALLY** |
| 11 | City of Brazil | Public Supply | WELL | 55 | Sand and Gravel | 600 | 2004 | 34400 |
| 11 | City of Brazil | Public Supply | WELL | 55 | Sand and Gravel | 600 | 2005 | 67400 |
| 11 | City of Brazil | Public Supply | WELL | 55 | Sand and Gravel | 60 | 2006 | 0 |
| 11 | City of Brazil | Public Supply | WELL | 54 | Sand and Gravel | 600 | 2004 | 135700 |
| 11 | City of Brazil | Public Supply | WELL | 54 | Sand and Gravel | 600 | 2005 | 134800 |
| 11 | City of Brazil | Public Supply | WELL | 54 | Sand and Gravel | 600 | 2006 | 149600 |
| 11 | City of Brazil | Public Supply | WELL | 54 | Sand and Gravel | 600 | 2004 | 135700 |
| 11 | City of Brazil | Public Supply | WELL | 54 | Sand and Gravel | 600 | 2005 | 134800 |
| 11 | City of Brazil | Public Supply | WELL | 54 | Sand and Gravel | 600 | 2006 | 149600 |
| 11 | City of Brazil | Public Supply | WELL | 60 | Sand and Gravel | 1260 | 2004 | 135700 |
| 11 | City of Brazil | Public Supply | WELL | 60 | Sand and Gravel | 1260 | 2005 | 134800 |
| 11 | City of Brazil | Public Supply | WELL | 60 | Sand and Gravel | 1260 | 2006 | 149600 |
| 11 | City of Brazil | Public Supply | WELL | 56 | Sand and Gravel | 787 | 2004 | 238400 |
| 11 | City of Brazil | Public Supply | WELL | 56 | Sand and Gravel | 787 | 2005 | 202200 |
| 11 | City of Brazil | Public Supply | WELL | 56 | Sand and Gravel | 787 | 2006 | 299300 |
| 12 | A &C Products | Industry | INTAKE | | Unknown Pit | 2800 | 2004 | 241600 |
| 12 | A &C Products | Industry | INTAKE | | Unknown Pit | 2800 | 2005 | 90600 |
| 12 | A &C Products | Industry | INTAKE | | Unknown Pit | 2800 | 2006 | 271800 |
| 12 | A &C Products | Industry | INTAKE | | Unknown Pit | 800 | 2004 | 0 |
| 12 | A &C Products | Industry | INTAKE | | Unknown Pit | 800 | 2005 | 0 |
| 12 | A &C Products | Industry | INTAKE | | Unknown Pit | 800 | 2006 | 0 |
| 13 | Reelsville Water | Public Supply | WELL | 92 | Sand and Gravel | 543 | 2006 | 72800 |
| 13 | Reelsville Water | Public Supply | WELL | 95 | Sand and Gravel | 543 | 2006 | 72800 |
| 13 | Reelsville Water | Public Supply | WELL | 62 | Sand and Gravel | 577 | 2006 | 72900 |
| 14 | American Aggregates | Industry | INTAKE | | Unnamed Quarry | 1175 | 2004 | 179300 |
| 14 | American Aggregates | Industry | INTAKE | | Unnamed Quarry | 1175 | 2005 | 124300 |
| 14 | American Aggregates | Industry | INTAKE | | Unnamed Quarry | 1175 | 2006 | 166500 |
| 14 | American Aggregates | Industry | INTAKE | | Unnamed Quarry | 3000 | 2004 | 35700 |
| 14 | American Aggregates | Industry | INTAKE | | Unnamed Quarry | 3000 | 2005 | 38900 |
| 14 | American Aggregates | Industry | INTAKE | | Unnamed Quarry | 3000 | 2006 | 26200 |

Creek. These SWWFs also represent important stakeholders in the protection and management of Big Walnut Creek.

# 5.0 WATER QUALITY ASSESSMENTS – EXISTING AND CURRENT

## 5.1 IDEM Data

A request was submitted to IDEM requesting both chemical and biological data that has been collected on the Big Walnut and Deer Creek Watersheds. Data was received from IDEM dating from 2002 to 2006. These sites were monitored on regular basis, but the frequency at which the site was monitored varies from site to site. Chemical and metal data was collected at four sites, fish data was collected at eight sites, and macroinvertebrate data at fifteen sites (Figure S). IDEM's Site 1 for chemical and metal data shows consistently high concentrations of nitrate. Site 1 also had high sediment concentrations. Site 1 is present in Subwatershed E. IDEM's Sites 3 and 4 for the chemical and metal data are the only sites reporting *E. coli* data from the collected data that we received from IDEM. These two sites were only sampled for *E. coli* during June of 2006 and show high *E. coli* concentrations. Site 3 is in Subwatershed D and Site 4 is in Subwatershed W. As noted in Section 4.1, twenty-nine segments of stream within the Big Walnut Watershed are listed for impairments according to the 303d list. Obviously, additional data was collected by IDEM to arrive at these listings; however, it was not made available to authors of this report as part of the data request.

## 5.2 Hoosier Riverwatch Data

Hoosier Riverwatch is a volunteer program run through IDNR Division of Fish and Wildlife. The purpose of the program is to increase public awareness of water quality throughout the State of Indiana by training volunteers to monitor the quality of local stream's water.

There has been little data regularly collected for the Big Walnut Creek Watershed (Eel 8-digit HUC). Available data dates from 2000 to 2007 and includes chemical, biological, habitat, and stream flow data. This data can be referenced in Table 7.

## 5.3 Current Data

Water quality monitoring was conducted within the watershed to identify nonpoint source pollution and critical areas. The sampling site locations covered the three primary counties, Boone, Hendricks, and Putnam. A number of these monitoring locations were located along streams segments that been identified as impaired. IDEM also conducted E. coli monitoring during five events (weekly) in October, 2007. Sample locations for monitoring associated with this plan, as well as IDEM's additional *E. coli* monitoring are shown on Figure T.

Current water quality monitoring conducted as part of this project consisted of chemical and macroinvertebrate sampling. Chemical sampling was conducted quarterly, beginning in May 2007 and macroinvertebrate sampling began in April 2007. Twenty-four sites within the watershed were sampled a total of six times for chemical parameters and twice for biological parameters. The water quality criteria analyzed included dissolved oxygen, biochemical oxygen demand, pH, total phosphate, nitrates, flow, total suspended solids, and *E. coli*. Collected samples of *E. coli* were cultured in the Commonwealth Biomonitoring laboratory for analysis.

Results of each water quality criteria sampled are displayed in Subsections 5.3.2 to 5.3.7 in Table format. The tables allow side by side comparison of a single criterion/parameter across all six sampling events. Several pollutants are shown as loads, rather than concentrations. This allows for a more accurate comparison of relative impacts in each subwatershed since flow is accounted for. Raw concentration data is included in Appendix E.

Loads for the pollutants were calculated as both an individual site average and as an overall watershed average. Averages were calculated using the first five samples. The sixth sample was not included as it was a part of the major storms that occurred in June and the data would skew the numbers. The average watershed nitrate load is 2162.03 tons/year. The average watershed total phosphorus load is 49.87 tons/year. The average watershed total suspended solids load is 3780.28 tons/year. The watershed average biochemical oxygen demand load is 3.24 tons/year.

*E.coli* averages were calculated as well, but not on a load basis. *E.coli* counts for the watershed average below the State single grab sample standard of 235 cfu/100mL at 212 cfu/100mL. This average is based upon the data collected for the project and not the data collected by IDEM for TMDL sampling. Even though the average is below the State standard many of the segments within the Big Walnut Creek Watershed are still impaired.

Monitoring of macroinvertebrates was performed twice (spring and fall) at all twenty-four sites within the watershed. The collected samples were analyzed using the State of Indiana's macroinvertebrate Index of Biotic Integrity (mIBI). A habitat assessment was also conducted at each site using the Qualitative Habitat Evaluation Index (QHEI) method set forth by the Ohio EPA. QHEI scores were used to aid in interpreting the mIBI scores.

Aquatic macroinvertebrates samples were collected using a dip net in riffle areas where the water current was 30cm/sec. Once samples were obtained they were preserved in the field with 70% isopropanol. A subsample of 100 organisms was prepared from each site by evenly distributing the organisms among randomly selected grids until 100 organisms had been selected from the entire sample. Each organism was then identified to the lowest possible taxon, typically genus or species. The results of the macroinvertebrate study were then analyzed by calculating metrics based on information about sensitivity of individual species to changes in environmental conditions.

A Quality Assurance Project Plan (QAPP) was developed and submitted to the State on April 2, 2007 and approved by IDEM on May 3, 2007 before monitoring activities began. Monitoring followed guidelines set forth in the approved QAPP.

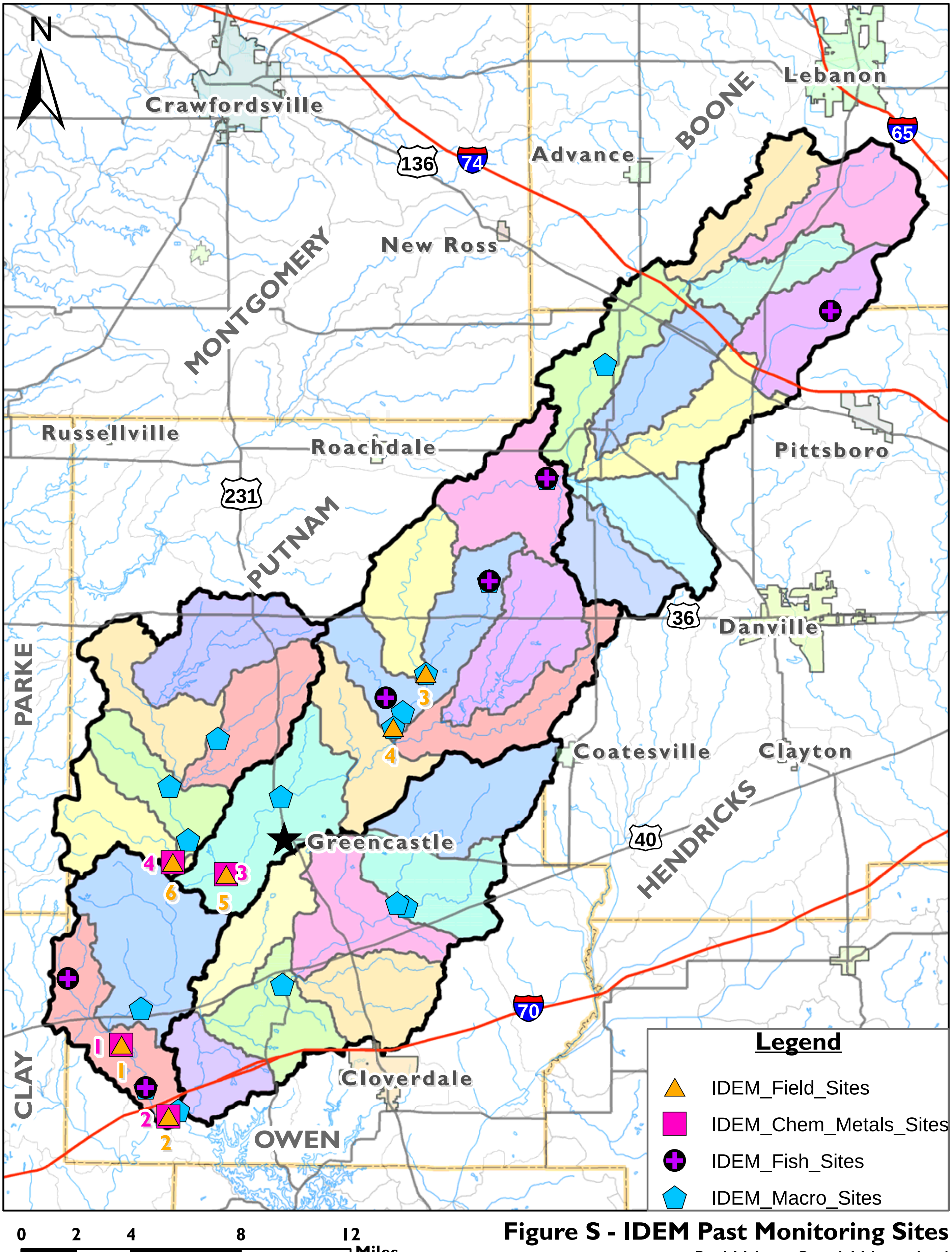



**Figure S - IDEM Past Monitoring Sites**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

**Table 7: Hoosier Riverwatch Data**

**Advanced Chemical Data**

| Site ID | Time | Date | Weather | Past Weather | Water Quality Score | DO (ppm) | DO (%Saturation) | pH | BOD 5(mg/L) | Temp Change (c) | Total Phosphate (mg/L) | Nitrate NO3 (mg/l) | Turbidity( NTU) | EColi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 118 | 9:30AM | 9/14/2000 | Clear/Sunny | Clear/Sunny | 73.55 | 11.5 | 110 | 8.57 | 2 | -0.1 | 0.78 | 5.03 | 38 | |
| 118 | 9:15 AM | 8/30/2001 | Clear/Sunny | Clear/Sunny | 80.31 | 8.33 | 92 | 8 | 1 | 0 | 0.65 | 2.75 | 42 | |
| 120 | 12:30p.m. | 10/11/2000 | Clear/Sunny | Clear/Sunny | 76 | 12.5 | 98 | 7.83 | 2.5 | 0.52 | 0.6 | 4.05 | 58.33 | |
| 120 | 9:25 | 2/14/2002 | Clear/Sunny | Clear/Sunny | 76.08 | 14.67 | 101.33 | 8 | 5 | 0 | 0.57 | 2.83 | 57 | |
| 120 | 9:30am | 9/2/2005 | Clear/Sunny | Clear/Sunny | NA | 9.87 | 102 | 8.33 | 1.67 | | | | 28.01 | |
| 210 | 9:30 AM | 4/5/2001 | Clear/Sunny | Clear/Sunny | 74.01 | 11 | 96 | 8 | 2.7 | -0.5 | 0.68 | 6.5 | 60 | |
| 210 | 9:30 AM | 9/10/2003 | Clear/Sunny | Clear/Sunny | NA | 8.6 | | 7.87 | 4.67 | 0.2 | 0 | | 44.33 | |
| 211 | 12:45 PM | 4/5/2001 | Clear/Sunny | Clear/Sunny | 69.54 | 12.67 | 124.67 | 8 | 3 | 0.3 | 0.8 | 9.5 | 60 | |
| 417 | 9:30 AM | 9/11/2004 | Clear/Sunny | Clear/Sunny | NA | 8 | 86 | 8 | | 1 | | 0 | 10 | |
| 696 | 10:30am | 9/25/2004 | Clear/Sunny | Clear/Sunny | 62.9 | 4 | 42 | 6 | 4 | -2 | 0 | 2 | 0 | 200 |
| 818 | 5:45 PM | 8/31/2004 | Clear/Sunny | Clear/Sunny | NA | 0 | 90 | 9 | | -2 | | 4.4 | 61 | |
| 889 | 1:00 PM | 1/10/2004 | Overcast | Clear/Sunny | NA | 19 | 135 | 8.2 | | 2 | | | 15.01 | |
| 889 | 9:00 AM | 4/28/2006 | Clear/Sunny | Overcast | N/A | 10 | 85 | 6.5 | | 1 | | 22 | 15.01 | |
| 889 | 1:00 PM | 9/17/2006 | Overcast | Clear/Sunny | N/A | 9.67 | 105 | | 5.5 | -0.5 | | 8.8 | 15.01 | |
| 889 | 9:30 AM | 5/4/2007 | Overcast | Overcast | 77.44 | 8.67 | 85 | 8.33 | 4.5 | 0 | | 5.13 | 15.01 | |
| 1046 | 4:00 PM | 5/29/2006 | Clear/Sunny | Clear/Sunny | 77.42 | 7 | 85 | 8.67 | 0 | 0 | | 22 | 15.01 | |
| 1046 | 12:00 PM | 9/16/2006 | Clear/Sunny | Stormy | N/A | 8 | 81 | | 1 | 0 | | 22 | 15.01 | |
| 1046 | 3:25 PM | 3/27/2007 | Clear/Sunny | Overcast | 84.04 | 9 | 95 | 8 | 0 | 0 | | 8.8 | 15.01 | |
| 1046 | 123:00 PM | 5/31/2007 | Overcast | Overcast | N/A | 8 | 100 | 9 | | | | 13.2 | 15.01 | |

**Stream Flow Data**

| Site ID | Time | Date | Weather | Past Weather | Ave Depth(ft) | Ave Width(ft) | Ave Velocity (ft/sec) | n value | Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|
| 120 | 9:25am | 2/14/2002 | Clear/Sunny | Clear/Sunny | 0.87 | 29.08 | 0.88 | 0.8 | 17.81 |
| 118 | 9:30 | 8/29/2002 | Clear/Sunny | Clear/Sunny | 0.89 | 24.33 | 2.73 | 0.9 | 53.2 |
| 696 | 7:00pm | 10/22/2003 | Clear/Sunny | Clear/Sunny | 1.35 | 67.4 | 0.61 | 0.8 | 44.4 |
| 696 | 5:30pm | 1/1/2003 | Clear/Sunny | Clear/Sunny | 1.31 | 70 | 0.6 | 0.8 | 44.02 |
| 696 | 10:00am | 4/14/2004 | Clear/Sunny | Overcast | 1.68 | 64.48 | 1.18 | 0.8 | 102.26 |
| 818 | 5:45 PM | 8/31/2004 | Clear/Sunny | Clear/Sunny | 0.92 | 7.5 | 0.2 | 0.9 | 1.24 |
| 696 | 10:30am | 9/25/2004 | Clear/Sunny | Clear/Sunny | 1.08 | 57.67 | 0.44 | 0.8 | 21.92 |
| 889 | 1:00 PM | 1/10/2004 | Overcast | Clear/Sunny | 0.8 | 42.67 | 0.95 | 0.9 | 29.19 |
| 120 | 9:30am | 9/2/2005 | Clear/Sunny | Clear/Sunny | 1.18 | 33.37 | 0.56 | 0.8 | 17.64 |
| 889 | 9:00 AM | 4/28/2006 | Clear/Sunny | Overcast | 1.31 | 68.33 | 1.82 | 0.8 | 130.33 |
| 1046 | 4:00 PM | 5/29/2006 | Clear/Sunny | Clear/Sunny | 0.36 | 13.17 | 0.5 | 0.8 | 1.9 |
| 1046 | 12:00 PM | 9/16/2006 | Clear/Sunny | Stormy | 0.23 | 5 | 0.22 | 0.8 | 0.2 |
| 1046 | 3:25 PM | 3/27/2007 | Clear/Sunny | Overcast | 0.45 | 15.77 | 1.45 | 0.8 | 8.23 |
| 889 | 9:30 AM | 5/4/2007 | Overcast | Overcast | 1.34 | 75.83 | 0.87 | 0.9 | 79.56 |
| 889 | 1:00 PM | 9/17/2006 | Overcast | Clear/Sunny | 0.69 | 53.67 | 1.62 | 0.8 | 47.99 |

**Table 7: Hoosier Riverwatch Data (cont)**

| Biological Data | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Time | Date | Weather | Past Weather | Pollution Tollerance Score | Stonefly Larvae | Mayfly Larvae | Caddis Fly Larve | Dobsonfly Larvae | Riffle Beetle | Water Penny | Right handed Snail | Damsel Fly Nymph | Dragonfly Nymph | Sowbug |
| 118 | 9:30 AM | 9/14/2000 | Clear/Sunny | Clear/Sunny | 23 | | 12 | 20 | | 3 | | 1 | | 1 | |
| 118 | 9:15 | 8/30/2001 | Clear/Sunny | Clear/Sunny | 29 | | 77 | 71 | 3 | 2 | | | | 3 | |
| 118 | 12:30pm | 8/29/2002 | Clear/Sunny | Clear/Sunny | 24 | | 20 | 3 | | 2 | | | 3 | 2 | |
| 120 | 12:30 | 10/11/2000 | Clear/Sunny | Clear/Sunny | 29 | | 38 | 17 | | 14 | | 1 | 13 | 1 | |
| 120 | 09:25am | 2/14/2002 | Clear/Sunny | Clear/Sunny | 18 | 4 | 22 | 17 | | | | | | | |
| 120 | 9:30am | 9/2/2005 | Clear/Sunny | Clear/Sunny | 26 | | 23 | 13 | | 5 | 10 | | 8 | 1 | |
| 210 | 9:30 AM | 4/5/2001 | Clear/Sunny | Clear/Sunny | 30 | | 25 | 31 | 8 | | | | 1 | 2 | 4 |
| 210 | 9:30 | 9/10/2003 | Clear/Sunny | Clear/Sunny | 39 | 5 | 20 | 1 | 2 | 11 | | 1 | 2 | 2 | |
| 211 | 12:45 PM | 4/5/2001 | Clear/Sunny | Clear/Sunny | 29 | | 20 | 12 | 1 | 3 | | | | 1 | |
| 364 | 9:30 | 9/27/2001 | Clear/Sunny | Clear/Sunny | 23 | | 108 | 84 | 9 | 1 | | | 2 | | |
| 417 | 11:00 AM | 6/30/2003 | Clear/Sunny | Clear/Sunny | 20 | | 5 | | 1 | | 8 | 4 | | | |
| 696 | 7:00pm | 10/22/2003 | Clear/Sunny | Clear/Sunny | 30 | | 6 | 5 | | 7 | 3 | 1 | 3 | 2 | |
| 696 | 10:00am | 4/14/2004 | Clear/Sunny | Overcast | 26 | 5 | 4 | 2 | | | 2 | | | | |
| 696 | 10:30am | 9/25/2004 | Clear/Sunny | Clear/Sunny | 25 | | 1 | 1 | | | 1 | 1 | | | |
| 818 | 5:45 PM | 8/31/2004 | Clear/Sunny | Clear/Sunny | 18 | | 2 | 1 | | | | | 3 | | |
| 889 | 1:00 PM | 10/21/2004 | Overcast | Clear/Sunny | 13 | | 16 | 12 | | | | | 1 | | |
| 889 | 9:00 AM | 4/28/2006 | Clear/Sunny | Overcast | 27 | 1 | 78 | 44 | 3 | | | | 2 | | |
| 889 | 1:00 PM | 9/17/2006 | Overcast | Clear/Sunny | 17 | 10 | 10 | 15 | | | | | | | |
| 889 | 9:30 AM | 5/4/2007 | Overcast | Overcast | 30 | 31 | 33 | 3 | | 2 | | | | | |
| 1046 | 4:00 PM | 5/29/2006 | Clear/Sunny | Clear/Sunny | 24 | | | 8 | | 1 | 5 | 20 | | | |
| 1046 | 12:00 PM | 9/16/2006 | Clear/Sunny | Stormy | 20 | | 5 | 8 | | | 5 | several | | | |
| 1046 | 123:00 PM | 5/31/2007 | Overcast | Overcast | 17 | | | 10 | | | 2 | 5 | | | |
| 1046 | 3:25 PM | 3/27/2007 | Clear/Sunny | Overcast | 25 | | 1 | 15 | | | 11 | 20 | | | 5 |

**Table 7: Hoosier Riverwatch Data (cont)**

| Habitat Data | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Time | Date | Weather | Past Weather | I | II | III | IV | V | VI | CQHEI |
| 118 | 9:30 AM | 9/14/2000 | Clear/Sunny | Clear/Sunny | 15 | 8 | 15 | 9 | 12 | 10 | 69 |
| 120 | 12:30 p.m | 10/11/2000 | Clear/Sunny | Clear/Sunny | 20 | 12 | 15 | 17 | 12 | 10 | 86 |
| 210 | 9:30 AM | 4/5/2001 | Clear/Sunny | Clear/Sunny | 19 | 12 | 9 | 10 | 7 | 13 | 70 |
| 211 | 12:45 PM | 4/5/2001 | Clear/Sunny | Clear/Sunny | 15 | 10 | 12 | 12 | 11 | 10 | 70 |
| 118 | 9:15am | 8/30/2001 | Clear/Sunny | Clear/Sunny | 10 | 10 | 15 | 8 | 12 | 10 | 65 |
| 120 | 9:25 | 2/14/2002 | Clear/Sunny | Clear/Sunny | 15 | 14 | 12 | 12 | 12 | 13 | 78 |
| 364 | 9:30 | 9/27/2001 | Clear/Sunny | Clear/Sunny | 15 | 16 | 12 | 10 | 14 | 10 | 77 |
| 118 | 9:30 a.m. | 8/29/2002 | Clear/Sunny | Clear/Sunny | 15 | 16 | 12 | 8 | 11 | 10 | 72 |
| 417 | 11:00 AM | 6/30/2003 | Clear/Sunny | Clear/Sunny | 20 | 14 | 18 | 19 | 7 | 9 | 87 |
| 211 | 9:30 | 9/10/2003 | Clear/Sunny | Clear/Sunny | 24 | 6 | 12 | 12.5 | 11 | 12 | 77.5 |
| 696 | 7:00pm | 10/23/2003 | Clear/Sunny | Clear/Sunny | 15 | 16 | 18 | 15 | 5 | 12 | 81 |
| 696 | 5:30pm | 1/23/2004 | Clear/Sunny | Clear/Sunny | 15 | 16 | 15 | 17 | 10 | 10 | 83 |
| 696 | 10:00am | 4/14/2004 | Clear/Sunny | Overcast | 15 | 18 | 15 | 14 | 12 | 15 | 89 |
| 818 | 5:45 PM | 8/31/2004 | Clear/Sunny | Clear/Sunny | 0 | 10 | 14 | 14 | 9 | 6 | 53 |
| 696 | 10:30am | 9/25/2004 | Clear/Sunny | Clear/Sunny | 15 | 18 | 15 | 14 | 8 | 11 | 81 |
| 818 | 2:30 PM | 11/1/2004 | Clear/Sunny | Clear/Sunny | 0 | 8 | 8 | 14 | 7 | 6 | 43 |
| 120 | 9:30am | 9/2/2005 | Clear/Sunny | Clear/Sunny | 20 | 10 | 15 | 16 | 13 | 10 | 84 |
| 889 | 9:00 AM | 4/28/2006 | Clear/Sunny | Overcast | 17 | 14 | 16.5 | 17 | 9 | 11.5 | 85 |
| 1046 | 4:00 PM | 5/29/2006 | Clear/Sunny | Clear/Sunny | 17 | 16 | 20 | 16.5 | 9 | 13 | 91.5 |
| 1046 | 3:25 PM | 3/27/2007 | Clear/Sunny | Overcast | 13 | 16 | 20 | 14.5 | 10 | 10.5 | 84 |

| Site ID | Description |
|---|---|
| 118 | Big Walnut Creek - Down stream of Houck Covered Bridge |
| 120 | Deer Creek - CR 375S bridge |
| 210 | Deweese Branch - Confluence with Deer Creek |
| 211 | Big Walnut Creek - Wildwood Bridge |
| 364 | Big Walnut Creek - Crowes Bridge |
| 417 | Deweese Branch - Limestone bottom creek flowing through wooded area with limestone outcroppings |
| 696 | Big Walnut Creek - McCloud Nature Park |
| 818 | Unnamed Tributary to Ramp Run - West CR 350N, Danville |
| 889 | Big Walnut Creek - Between Pine Bluff and Rolling Stone Covered Bridges |
| 1046 | Unnamed Tributary to Big Wanut Creek - Tributary to West Fork Big Walnut Creek |

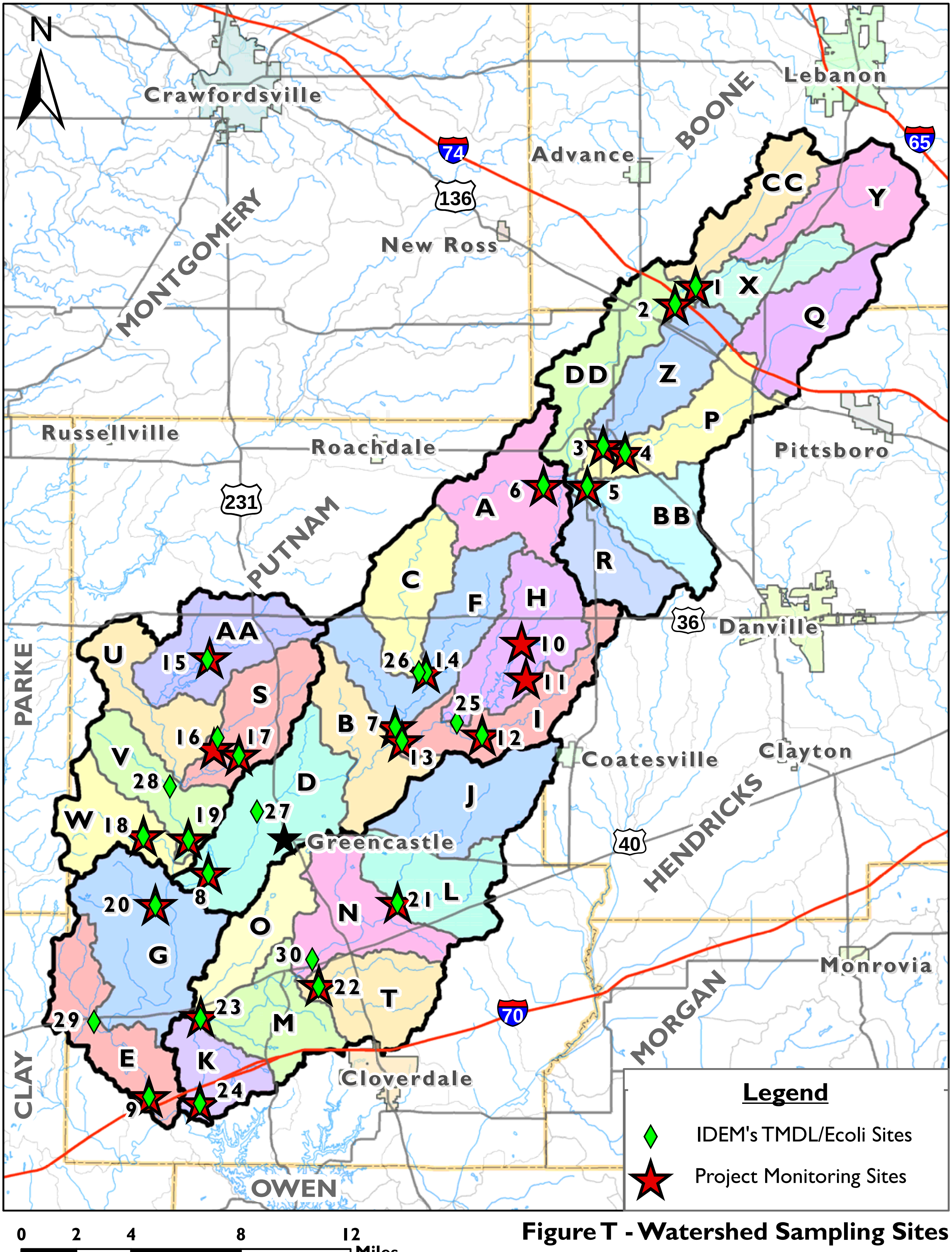



**Figure T - Watershed Sampling Sites**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

### 5.3.1 Flow Measurements

Flow data were gathered from the USGS Gauge at Roachdale along Big Walnut Creek. Flow at this site is for a drainage area of 131 square miles. Flow at all other sites was extrapolated as a proportion of this flow. For example, if a sampling site has a drainage area of 13 square miles, the flow is ten percent of the flow at Roachdale. Changes in storm flows relative to base flow data can also demonstrate the 'flashiness' of the stream (i.e. its response to run-off events). Table 8 displays flow data for each sample site at each sample event.

**Table 8: Flow Data**

| **Flow Data (cfs)**<br>Flow data is calculated from USGS Roachdale Gauge | | | | | | |
|---|---|---|---|---|---|---|
| | **5/29/07** | **7/11/07** | **8/28/07** | **1/8/08** | **4/10/08** | **6/4/08*** |
| | Storm | Base | Base | Storm | Base | Storm |
| **USGS Gauge Flow** | 42 | 8.5 | 6.5 | 35 | 100 | 7000 |
| **Site 1 -** Watershed X, Y | 7.1 | 1.4 | 1.1 | 6.0 | 17.0 | 1190.0 |
| **Site 2 -** Watershed CC | 3.4 | 0.7 | 0.5 | 2.8 | 8.0 | 560.0 |
| **Site 3 -** Watershed Z | 4.6 | 0.9 | 0.7 | 3.9 | 11.0 | 770.0 |
| **Site 4 -** Watershed P, Q | 8.0 | 1.6 | 1.2 | 6.7 | 19.0 | 1330.0 |
| **Site 5 -** Watershed BB, R | 7.6 | 1.5 | 1.2 | 6.3 | 18.0 | 1260.0 |
| **Site 6 -** Watershed DD | 38.2 | 7.7 | 5.9 | 31.9 | 91.0 | 6370.0 |
| **Site 7 -** Watersheds A, C, F | 46.6 | 9.4 | 7.2 | 38.9 | 111.0 | 7770.0 |
| **Site 8 -** Watershed B, D | 72.2 | 14.6 | 11.2 | 60.2 | 172.0 | 12040.0 |
| **Site 9 -** Watershed E, G | 107.5 | 21.8 | 16.6 | 89.6 | 256.0 | 17920.0 |
| **Site 10 -** Watershed H | 2.9 | 0.6 | 0.5 | 2.5 | 7.0 | 490.0 |
| **Site 11 -** Watershed H | 1.7 | 0.3 | 0.0 | 1.4 | 4.0 | 280.0 |
| **Site 12 -** Watershed I | 3.4 | 0.7 | 0.5 | 2.8 | 8.0 | 560.0 |
| **Site 13 -** Watershed I | 9.7 | 2.0 | 1.5 | 8.1 | 23.0 | 1610.0 |
| **Site 14 -** Watershed F | 3.4 | 0.7 | 0.5 | 2.8 | 8.0 | 560.0 |
| **Site 15 -** Watershed AA | 4.6 | 0.9 | 0.7 | 3.9 | 11.0 | 770.0 |
| **Site 16 -** Watershed S | 2.1 | 0.4 | 0.3 | 1.8 | 5.0 | 350.0 |
| **Site 17 -** Watershed S | 2.1 | 0.4 | 0.0 | 1.8 | 5.0 | 350.0 |
| **Site 18 -** Watershed W | 2.9 | 0.6 | 0.5 | 2.5 | 7.0 | 490.0 |
| **Site 19 -** Watershed U, V | 15.5 | 3.1 | 2.4 | 13.0 | 37.0 | 2590.0 |
| **Site 20 -** Watershed G | 2.5 | 0.5 | 0.4 | 2.1 | 6.0 | 420.0 |
| **Site 21 -** Watershed L, J | 6.7 | 1.4 | 1.0 | 5.6 | 16.0 | 1120.0 |
| **Site 22 -** Watershed T | 3.8 | 0.8 | 0.6 | 3.2 | 9.0 | 630.0 |
| **Site 23 -** Watershed O | 3.4 | 0.7 | 0.5 | 2.8 | 8.0 | 560.0 |
| **Site 24 -** Watershed K, M, N | 27.3 | 5.5 | 4.2 | 22.8 | 65.0 | 4550.0 |

*Approximately 1.5 inches of rain was received June 3-June 4, representing an above average storm event sampling.

### 5.3.2 Dissolved Oxygen (DO)

Dissolved oxygen is a measure of the amount of oxygen available in the water for fish, macroinvertebrates and other wildlife. When excessive nutrients from sources such as fertilizers and wastewaters enter the water, plants and algae will flourish. When excess aquatic plants and algae begin to decay or die they remove a significant amount of oxygen from the water which can often cause a fish kill or degraded conditions for other wildlife. Low DO levels often signal non-point source pollution problems. There are several factors that influence dissolved oxygen levels. They include: temperature, plant growth and photosynthesis, and amount of decaying organic matter.

Sites that displayed DO levels at or below the State water quality standard of 5 mg/L during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed "hotspots."

**Table 9: Dissolved Oxygen**

| **Dissolved Oxygen (DO) mg/L** | | | | | | |
|---|---|---|---|---|---|---|
| | **5/29/07** | **7/11/07** | **8/28/07** | **1/8/08** | **4/10/08** | **6/4/08** |
| | Storm | Base | Base | Storm | Base | Storm |
| **Site 1 -** Watershed X, Y | 8.1 | 7.3 | 6.7 | 9.5 | 10.5 | 7.0 |
| **Site 2 -** Watershed CC | 12 | 6.3 | 5.0 | 10.5 | 10.6 | 6.7 |
| **Site 3 -** Watershed Z | 9.1 | 8.4 | 9.4 | 10.5 | 11.9 | 7.8 |
| **Site 4 -** Watershed P, Q | 9.1 | 7.5 | 8.0 | 9.6 | 11.6 | 6.8 |
| **Site 5 -** Watershed BB, R | 8.6 | 5.7 | 6.4 | 10.0 | 10.5 | 8.0 |
| **Site 6 -** Watershed DD | 9.0 | 8.2 | 8.4 | 10.0 | 10.9 | 7.9 |
| **Site 7 -** Watersheds A, C, F | 8.7 | 6.8 | 7.0 | 9.8 | 10.6 | 8.0 |
| **Site 8 -** Watershed B, D | 11.1 | 8.6 | 7.8 | 12.4 | 11.9 | 8.1 |
| **Site 9 -** Watershed E, G | 9.7 | 8.1 | 8.2 | 12.8 | 11.7 | 9.7 |
| **Site 10 -** Watershed H | 6.7 | 7.8 | 7.5 | 9.8 | 10.7 | 8.2 |
| **Site 11 -** Watershed H | 8.1 | 5.0 | 3.6 | 9.9 | 10.2 | 8.1 |
| **Site 12 -** Watershed I | 8.9 | 4.2 | 4.4 | 8.1 | 10.5 | 8.2 |
| **Site 13 -** Watershed I | 8.0 | 8.4 | 4.7 | 9.4 | 10.2 | 7.9 |
| **Site 14 -** Watershed F | 10.6 | 8.2 | 7.3 | 9.8 | 10.5 | 8.4 |
| **Site 15 -** Watershed AA | 9.8 | 6.2 | 6.6 | 11.2 | 13.1 | 12.4 |
| **Site 16 -** Watershed S | 10.1 | 7.7 | 6.7 | 12.5 | 13.4 | 15.2 |
| **Site 17 -** Watershed S | 8.7 | 6.7 | 3.3 | 12.6 | 13.9 | 14.8 |
| **Site 18 -** Watershed W | 9.8 | 7.4 | 6.5 | 13.1 | 13.7 | 8.7 |
| **Site 19 -** Watershed U, V | 11.3 | 8.5 | 7.0 | 11.7 | 12.7 | 14.2 |
| **Site 20 -** Watershed G | 8.9 | 7.6 | 8.1 | 12.7 | 13.6 | 7.8 |
| **Site 21 -** Watershed L, J | 10.1 | 6.4 | 6.8 | 12.2 | 13.1 | 9.4 |
| **Site 22 -** Watershed T | 9 | 8.1 | 6.8 | 14.2 | 12.5 | 10.2 |
| **Site 23 -** Watershed O | 10.2 | 6.7 | 6.8 | 12.2 | 12.0 | 9.2 |
| **Site 24 -** Watershed K, M, N | 8.6 | 6.1 | 7.3 | 13.1 | 11.6 | 9.3 |

Percent saturation is the result of comparing the level of dissolved oxygen present in water to the total amount of dissolved oxygen that water is able to hold at a given temperature and pressure. Sites that displayed percent saturation values lower than 70% were highlighted to assist in identification of sites experiencing conditions stressful to aquatic life. Sites with percent saturation values higher than 115% were highlighted to assist in identification of sites likely experiencing algal bloom, as indicator of nutrient enrichment.

**Table 10: Percent Saturation**

| **Percent Saturation** | | | | | | |
|---|---|---|---|---|---|---|
| | **5/29/07** | **7/11/07** | **8/28/07** | **1/8/08** | **4/10/08** | **6/4/08** |
| | Storm | Base | Base | Storm | Base | Storm |
| **Site 1 -** Watershed X, Y | 94.2 | 86.9 | 82.7 | 94.1 | 100.0 | 89.7 |
| **Site 2 -** Watershed CC | 148.2 | 73.3 | 61.7 | 104.0 | 98.2 | 82.7 |
| **Site 3 -** Watershed Z | 108.3 | 97.7 | 111.9 | 104.0 | 110.2 | 94.0 |
| **Site 4 -** Watershed P, Q | 105.8 | 89.3 | 85.2 | 93.2 | 104.4 | 84.0 |
| **Site 5 -** Watershed BB, R | 100.0 | 66.3 | 74.4 | 97.1 | 100.0 | 95.2 |
| **Site 6 -** Watershed DD | 104.7 | 98.8 | 101.2 | 99.0 | 101.0 | 94.1 |
| **Site 7 -** Watersheds A, C, F | 101.2 | 81.9 | 84.3 | 93.3 | 96.4 | 92.0 |
| **Site 8 -** Watershed B, D | 129.1 | 103.6 | 91.8 | 95.4 | 103.9 | 87.1 |
| **Site 9 -** Watershed E, G | 112.1 | 96.4 | 95.4 | 103.2 | 104.9 | 105.4 |
| **Site 10 -** Watershed H | 79.8 | 89.7 | 87.2 | 95.2 | 99.1 | 95.4 |
| **Site 11 -** Watershed H | 93.1 | 60.2 | 41.9 | 96.1 | 94.4 | 94.2 |
| **Site 12 -** Watershed I | 100.0 | 48.8 | 50.6 | 77.1 | 100.0 | 92.1 |
| **Site 13 -** Watershed I | 86.0 | 101.2 | 54.7 | 89.5 | 94.4 | 90.8 |
| **Site 14 -** Watershed F | 121.8 | 95.4 | 83.9 | 93.3 | 95.5 | 96.9 |
| **Site 15 -** Watershed AA | 112.6 | 77.0 | 80.6 | 103.7 | 111.7 | 129.2 |
| **Site 16 -** Watershed S | 112.2 | 89.5 | 75.3 | 105.9 | 110.7 | 156.7 |
| **Site 17 -** Watershed S | 103.6 | 77.0 | 39.3 | 101.6 | 115.7 | 152.6 |
| **Site 18 -** Watershed W | 119.7 | 84.1 | 72.2 | 104.8 | 116.1 | 90.2 |
| **Site 19 -** Watershed U, V | 132.9 | 101.2 | 79.6 | 91.4 | 108.3 | 147.2 |
| **Site 20 -** Watershed G | 97.8 | 86.4 | 92.1 | 105.0 | 115.3 | 80.8 |
| **Site 21 -** Watershed L, J | 114.8 | 74.0 | 77.3 | 109.4 | 114.4 | 101.1 |
| **Site 22 -** Watershed T | 96.8 | 92.1 | 77.3 | 127.4 | 105.9 | 110.9 |
| **Site 23 -** Watershed O | 117.2 | 74.4 | 75.6 | 105.2 | 101.7 | 101.1 |
| **Site 24 -** Watershed K, M, N | 96.6 | 74.5 | 83.0 | 109.1 | 101.0 | 101.1 |

### 5.3.3 Nitrate (NO3)

Nitrate is a form of nitrogen. Nitrogen is present in all living things and composes about 80% of the air we breathe. Nitrogen is a source of pollution to water when it becomes present in excessive amounts. Increased nitrogen leads to increased plant growth resulting in algal blooms in lakes and streams. Nitrate is a common inorganic nutrient found in commercial fertilizer, septic system waste, animal feed lot runoff, agricultural fertilizers, manure, industrial waste waters, and sanitary waste water including landfill leachate.

Sites that displayed the highest NO3 levels (upper third of the 24 sites, eight (8) sites) during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed "hotspots." There is nothing scientific about the values highlighted, rather they represent a simple, relative comparison across sites to help determine rough trends.

**Table 11: Nitrate**

| Nitrates (NO3) tons/year | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **5/29/07** | **7/11/07** | **8/28/07** | **1/8/08** | **4/10/08** | **6/4/08** | **Average** |
| | Storm | Base | Base | Storm | Base | Storm | 1st 5 events |
| **Site 1 -** Watershed X, Y | 8.44 | 0.97 | 1.63 | 44.32 | 100.46 | 4453.78 | 31.16 |
| **Site 2 -** Watershed CC | 9.93 | 0.48 | 1.48 | 22.06 | 59.09 | 1544.34 | 18.51 |
| **Site 3 -** Watershed Z | 11.83 | 2.13 | 1.24 | 24.97 | 56.34 | 3185.21 | 19.30 |
| **Site 4 -** Watershed P, Q | 14.93 | 1.10 | 1.42 | 49.49 | 112.28 | 4584.77 | 35.84 |
| **Site 5 -** Watershed BB, R | 15.64 | 0.59 | 1.54 | 40.33 | 106.37 | 2357.88 | 32.89 |
| **Site 6 -** Watershed DD | 67.76 | 3.03 | 6.97 | 175.94 | 537.76 | 12547.79 | 158.29 |
| **Site 7 -** Watersheds A, C, F | 82.65 | 3.70 | 5.67 | 214.55 | 524.76 | 26784.70 | 166.27 |
| **Site 8 -** Watershed B, D | 135.19 | 15.82 | 14.34 | 260.88 | 338.81 | 22530.86 | 153.01 |
| **Site 9 -** Watershed E, G | 137.67 | 8.59 | 11.44 | 335.34 | 806.84 | 38829.20 | 259.98 |
| **Site 10 -** Watershed H | 2.03 | 0.12 | 0.34 | 7.39 | 19.30 | 1930.43 | 5.84 |
| **Site 11 -** Watershed H | 5.29 | 0.18 | 0.00 | 8.96 | 20.49 | 1323.72 | 1071.73 |
| **Site 12 -** Watershed I | 2.98 | 0.14 | 0.34 | 11.58 | 18.91 | 2095.89 | 6.79 |
| **Site 13 -** Watershed I | 24.74 | 1.18 | 1.48 | 35.10 | 72.49 | 3805.70 | 27.00 |
| **Site 14 -** Watershed F | 2.98 | 0.28 | 0.30 | 9.65 | 19.70 | 1930.43 | 6.58 |
| **Site 15 -** Watershed AA | 13.65 | 0.53 | 0.62 | 23.05 | 20.58 | 3033.53 | 11.69 |
| **Site 16 -** Watershed S | 7.24 | 0.24 | 0.24 | 8.86 | 24.62 | 827.33 | 8.24 |
| **Site 17 -** Watershed S | 4.96 | 0.35 | 0.00 | 10.28 | 32.99 | 758.38 | 9.72 |
| **Site 18 -** Watershed W | 4.05 | 0.47 | 0.34 | 5.42 | 10.34 | 1158.26 | 4.12 |
| **Site 19 -** Watershed U, V | 42.86 | 3.36 | 3.07 | 28.17 | 87.46 | 4081.48 | 32.98 |
| **Site 20 -** Watershed G | 2.98 | 0.25 | 0.20 | 1.45 | 4.14 | 537.76 | 1.80 |
| **Site 21 -** Watershed L, J | 12.58 | 0.55 | 0.98 | 22.06 | 55.16 | 3199.00 | 18.27 |
| **Site 22 -** Watershed T | 37.23 | 0.71 | 0.77 | 9.46 | 21.27 | 1799.44 | 13.89 |
| **Site 23 -** Watershed O | 8.60 | 0.41 | 0.49 | 6.07 | 9.46 | 882.48 | 5.01 |
| **Site 24 -** Watershed K, M, N | 94.11 | 4.33 | 4.14 | 78.60 | 134.44 | 7170.16 | 63.12 |
| **Overall** (sum sites 1-24) | 6074.03 | 49.03 | 59.04 | 1433.98 | 3194.06 | 151352.5 | 2162.03 |

### 5.3.4 Total Phosphorus (TP)

Phosphorus is an essential element for plant and animal life. It is a naturally occurring element found in rocks that is often mined for commercial fertilizer production. Aquatic life develops with low levels of phosphorus, but phosphorus becomes a problem in water quality when its presence becomes excessive. Excessive amounts of phosphorus can lead to problematic algal blooms causing depleted dissolve oxygen supplies and leading to eutrophication (aging/degradation) of lakes and other water bodies. Total Phosphorus includes inorganic and organic types of phosphorus. Increased phosphorus levels result from discharge of phosphorus-containing pollutants into surface waters. Sources of phosphorus include naturally occurring organic matter such as leaf litter, grass clipping and decaying plants and animals, as well as human and domestic animal waste and commercial and agricultural fertilizers.

Sites that displayed the highest TP levels (upper third of the 24 sites, eight (8) sites) during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed "hotspots." There is nothing scientific about the values highlighted, rather they represent a simple, relative comparison across sites to help determine rough trends.

**Table 12: Phosphorus**

| **Total Phosphorus (TP) tons/year** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **5/29/07** | **7/11/07** | **8/28/07** | **1/8/08** | **4/10/08** | **6/4/08** | **Average** |
| | Storm | Base | Base | Storm | Base | Storm | 1st 5 events |
| **Site 1 -** Watershed X, Y | 1.55 | 0.36 | 0.14 | .24 | 0.5 | 468.82 | 0.56 |
| **Site 2 -** Watershed CC | 0.13 | 0.07 | 0.04 | .11 | 0.39 | 523.97 | 0.15 |
| **Site 3 -** Watershed Z | 1.18 | 0.09 | 0.17 | .12 | 0.98 | 606.71 | 0.51 |
| **Site 4 -** Watershed P, Q | 1.34 | 0.55 | 0.22 | .40 | 2.99 | 681.17 | 1.10 |
| **Site 5 -** Watershed BB, R | 1.27 | 0.30 | 0.11 | .37 | 1.06 | 1178.94 | 0.62 |
| **Site 6 -** Watershed DD | 16.19 | 2.43 | 1.10 | 1.57 | 4.48 | 2635.04 | 5.15 |
| **Site 7 -** Watersheds A, C, F | 11.02 | 0.74 | 1.13 | 1.92 | 8.75 | 3979.44 | 4.71 |
| **Site 8 -** Watershed B, D | 17.79 | 2.59 | 2.10 | 2.96 | 13.55 | 6166.34 | 7.80 |
| **Site 9 -** Watershed E, G | 42.36 | 5.15 | 4.25 | 4.41 | 32.78 | 10589.78 | 17.79 |
| **Site 10 -** Watershed H | 0.69 | 0.06 | 0.04 | 0.15 | 0.41 | 386.09 | 0.27 |
| **Site 11 -** Watershed H | 0.99 | 0.06 | 0.00 | 0.08 | 0.51 | 261.99 | 0.33 |
| **Site 12 -** Watershed I | 1.85 | 0.17 | 0.10 | 0.14 | 0.55 | 523.97 | 0.56 |
| **Site 13 -** Watershed I | 1.81 | 0.22 | 0.21 | 0.80 | 2.04 | 1427.14 | 1.02 |
| **Site 14 -** Watershed F | 0.10 | 0.08 | 0.16 | 0.17 | 0.55 | 286.81 | 0.21 |
| **Site 15 -** Watershed AA | 1.09 | 0.17 | 0.15 | 0.27 | 0.76 | 288.19 | 0.49 |
| **Site 16 -** Watershed S | 0.50 | 0.06 | 0.05 | 0.11 | 0.98 | 144.78 | 0.34 |
| **Site 17 -** Watershed S | 0.25 | 0.09 | 0.00 | 0.12 | 0.44 | 82.73 | 0.18 |
| **Site 18 -** Watershed W | 1.01 | 0.08 | 0.11 | 0.17 | 0.21 | 106.17 | 0.32 |
| **Site 19 -** Watershed U, V | 1.38 | 0.27 | 0.57 | 1.28 | 1.09 | 459.17 | 0.92 |
| **Site 20 -** Watershed G | 0.15 | 0.16 | 0.06 | 0.19 | 0.18 | 99.28 | 0.15 |
| **Site 21 -** Watershed L, J | 0.79 | 0.15 | 0.28 | 0.33 | 0.63 | 882.48 | 0.44 |
| **Site 22 -** Watershed T | 0.56 | 0.12 | 0.07 | 0.38 | 1.51 | 235.79 | 0.53 |
| **Site 23 -** Watershed O | 0.50 | 0.15 | 0.07 | 0.28 | 0.55 | 121.34 | 0.31 |
| **Site 24 -** Watershed K, M, N | 24.17 | 0.98 | 0.99 | 1.80 | 3.20 | 1075.52 | 5.43 |
| **Overall** (sum sites 1-24) | 124.67 | 15.1 | 12.12 | 18.37 | 79.09 | 33211.66 | 49.87 |

### 5.3.5 Total Suspended Solids (TSS)

Total Suspended Solids (TSS) are solid materials suspended in water and include such things as soil particles and industrial waste. TSS lower water quality by absorbing light resulting in warmer waters that have less ability to hold oxygen. Less light also decreases the amount of photosynthesis by plants and thus reduces the amount of oxygen produced by the plants. TSS can also have an impact on life by clogging fish gills, suffocating eggs and larvae, and obstructing habitats of microinvertebrates (aquatic insects).

Sites that displayed the highest TSS levels (upper third of the 24 sites, eight (8) sites) during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed "hotspots." There is nothing scientific about the values highlighted, rather they represent a simple, relative comparison across sites to help determine rough trends.

**Table 13: Total Suspended Solids**

| **Total Suspended Solids (TSS) tons/year** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **5/29/07** | **7/11/07** | **8/28/07** | **1/8/08** | **4/10/08** | **6/4/08** | **Average** |
| | Storm | Base | Base | Storm | Base | Storm | 1st 5 events |
| **Site 1 -** Watershed X, Y | 31.65 | 9.65 | 5.42 | 88.64 | 133.95 | 632904.90 | 53.86 |
| **Site 2 -** Watershed CC | 62.88 | 2.76 | 6.65 | 26.20 | 114.25 | 247094.90 | 42.55 |
| **Site 3 -** Watershed Z | 13.65 | 3.55 | 3.79 | 13.44 | 21.67 | 183528.63 | 11.22 |
| **Site 4 -** Watershed P, Q | 15.72 | 4.73 | 10.05 | 19.80 | 74.85 | 241027.84 | 25.03 |
| **Site 5 -** Watershed BB, R | 29.78 | 58.36 | 5.32 | 15.51 | 70.91 | 488950.06 | 35.98 |
| **Site 6 -** Watershed DD | 112.93 | 64.46 | 31.96 | 172.80 | 1971.80 | 1693951.36 | 470.79 |
| **Site 7 -** Watersheds A, C, F | 137.75 | 60.18 | 42.55 | 421.44 | 765.28 | 4101885.63 | 285.44 |
| **Site 8 -** Watershed B, D | 355.75 | 136.61 | 55.16 | 681.86 | 1863.45 | 10672514.03 | 618.57 |
| **Site 9 -** Watershed E, G | 794.23 | 203.98 | 130.80 | 970.73 | 5799.17 | 16555358.21 | 1579.78 |
| **Site 10 -** Watershed H | 169.40 | 2.95 | 0.98 | 1.23 | 34.47 | 162156.03 | 41.81 |
| **Site 11 -** Watershed H | 20.68 | 1.18 | 0.00 | 6.20 | 82.73 | 153882.76 | 22.16 |
| **Site 12 -** Watershed I | 16.55 | 6.20 | 3.20 | 5.52 | 48.85 | 616634.14 | 16.06 |
| **Site 13 -** Watershed I | 71.36 | 54.17 | 6.65 | 127.64 | 215.20 | 716740.67 | 95.00 |
| **Site 14 -** Watershed F | 4.96 | 8.27 | 2.71 | 5.52 | 35.46 | 516251.84 | 11.38 |
| **Site 15 -** Watershed AA | 4.55 | 12.41 | 10.69 | 21.13 | 124.59 | 517217.06 | 34.67 |
| **Site 16 -** Watershed S | 4.14 | 0.79 | 0.59 | 0.89 | 22.16 | 116515.17 | 5.71 |
| **Site 17 -** Watershed S | 5.17 | 3.15 | 0.00 | 1.77 | 22.16 | 121341.24 | 6.45 |
| **Site 18 -** Watershed W | 1.45 | 3.25 | 1.48 | 13.54 | 41.37 | 209451.54 | 12.22 |
| **Site 19 -** Watershed U, V | 22.96 | 32.06 | 23.64 | 76.82 | 127.55 | 1270360.10 | 56.61 |
| **Site 20 -** Watershed G | 1.24 | 0.98 | 0.20 | 3.10 | 11.82 | 121617.02 | 3.47 |
| **Site 21 -** Watershed L, J | 9.93 | 28.27 | 2.46 | 8.27 | 70.91 | 425797.46 | 23.97 |
| **Site 22 -** Watershed T | 78.18 | 21.27 | 4.14 | 9.46 | 84.21 | 174979.59 | 39.45 |
| **Site 23 -** Watershed O | 14.89 | 3.79 | 2.71 | 9.65 | 66.97 | 132372.27 | 19.60 |
| **Site 24 -** Watershed K, M, N | 416.77 | 151.68 | 95.14 | 134.74 | 544.16 | 3405828.12 | 268.50 |
| **Overall** (sum sites 1-24) | 2396.57 | 874.7 | 446.29 | 2835.90 | 12347.9 | 43478361 | 3780.28 |

### 5.3.6 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is a measure of the quantity of oxygen used by microorganisms (aerobic bacteria) in the oxidation (break-down) of organic matter. Streams with high quantities of plant growth and decay generally have high levels of biochemical oxygen levels. The higher the number, the more indicative the site is of higher pollution loads.

Sites that displayed the highest BOD levels (upper third of the 24 sites, eight (8) sites) during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed "hotspots." There is nothing scientific about the values highlighted, rather they represent a simple, relative comparison across sites to help determine rough trends.

**Table 14: Biochemical Oxygen Demand**

| **Biochemical Oxygen Demand (BOD) tons/year** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **5/29/07** | **7/11/07** | **8/28/07** | **1/8/08** | **4/10/08** | **6/4/08** | **Average** |
| | Storm | Base | Base | Storm | Base | Storm | 1st 5 events |
| **Site 1 -** Watershed X, Y | 12.66 | 4.00 | 3.25 | 4.73 | 10.05 | 3281.73 | 1.10 |
| **Site 2 -** Watershed CC | 3.97 | 1.03 | 1.77 | 3.86 | 3.15 | 3309.31 | 0.16 |
| **Site 3 -** Watershed Z | 6.83 | 1.51 | 1.65 | 6.53 | 4.33 | 6370.42 | 0.67 |
| **Site 4 -** Watershed P, Q | 12.58 | 3.47 | 3.55 | 7.92 | 14.97 | 7859.60 | 1.60 |
| **Site 5 -** Watershed BB, R | 13.40 | 4.58 | 3.43 | 9.93 | 19.50 | 8935.13 | 3.13 |
| **Site 6 -** Watershed DD | 56.47 | 15.93 | 17.43 | 47.13 | 134.44 | 20076.46 | 9.68 |
| **Site 7 -** Watersheds A, C, F | 82.65 | 18.52 | 19.86 | 53.64 | 10.93 | 33672.20 | 6.50 |
| **Site 8 -** Watershed B, D | 106.73 | 28.76 | 40.81 | 83.01 | 101.64 | 75893.43 | 12.03 |
| **Site 9 -** Watershed E, G | 158.85 | 47.24 | 49.05 | 158.85 | 25.21 | 84718.25 | 22.92 |
| **Site 10 -** Watershed H | 9.56 | 0.83 | 1.28 | 2.71 | 0.69 | 2895.64 | 0.62 |
| **Site 11 -** Watershed H | 4.30 | 3.01 | 0.00 | 1.52 | 1.18 | 1654.65 | 0.80 |
| **Site 12 -** Watershed I | 5.96 | 1.65 | 1.48 | 3.03 | 6.30 | 4191.79 | 1.07 |
| **Site 13 -** Watershed I | 12.37 | 5.52 | 5.76 | 15.16 | 49.84 | 13954.24 | 2.26 |
| **Site 14 -** Watershed F | 2.65 | 0.55 | 1.03 | 3.86 | 4.73 | 3088.69 | 0.24 |
| **Site 15 -** Watershed AA | 5.92 | 1.77 | 2.62 | 8.45 | 14.08 | 5157.00 | 0.91 |
| **Site 16 -** Watershed S | 2.48 | 0.16 | 0.68 | 2.30 | 2.95 | 2481.98 | 0.34 |
| **Site 17 -** Watershed S | 3.10 | 0.91 | 0.00 | 2.30 | 2.95 | 1654.65 | 0.23 |
| **Site 18 -** Watershed W | 4.63 | 0.24 | 1.03 | 3.45 | 6.20 | 2123.47 | 0.54 |
| **Site 19 -** Watershed U, V | 32.14 | 4.27 | 5.44 | 26.89 | 0.00 | 13264.84 | 1.69 |
| **Site 20 -** Watershed G | 3.97 | 0.30 | 0.95 | 2.48 | 0.00 | 1820.12 | 0.16 |
| **Site 21 -** Watershed L, J | 33.09 | 1.24 | 2.17 | 6.07 | 1.58 | 6618.61 | 1.19 |
| **Site 22 -** Watershed T | 7.07 | 0.08 | 1.60 | 4.41 | 2.66 | 2730.18 | 0.50 |
| **Site 23 -** Watershed O | 5.29 | 0.41 | 1.13 | 3.59 | 3.94 | 2868.07 | 0.39 |
| **Site 24 -** Watershed K, M, N | 53.78 | 4.88 | 11.17 | 31.44 | 0.37 | 5487.23 | 10.84 |
| **Overall** (sum site 1-24) | 10.02 | 1.47 | 1.76 | 1.39 | 1.55 | 314107.7 | 3.24 |

### 5.3.7 E. coli

*E. coli* is a specific species of fecal coliform bacteria, which are found in the feces of warm-blooded animals. *E. coli* enter our waters from combined sewer overflows (CSOs), failing septic systems, livestock in streams, agricultural feedlot runoff, wildlife, and urban runoff from domestic pet waste. Not all, but certain strains of *E. coli* can cause illness in humans. Those that are not pathogenic may occur with other intestinal pathogens and cause health problems.
Sites that displayed *E. coli* levels at or below the State water quality standard of 235 cfu/100mL during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed "hotspots."

**Table 15: *E. coli***

| *E. coli* cfu/100mL | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **5/29/07** | **7/11/07** | **8/28/07** | **1/8/08** | **4/10/08** | **6/4/08** | **Average** |
| | Storm | Base | Base | Storm | Base | Storm | 1st 5 events |
| **Site 1 -** Watershed X, Y | 218 | 494 | 441 | 262 | 182 | 2975 | 319.4 |
| **Site 2 -** Watershed CC | 87 | 117 | 170 | 103 | 67 | 1510 | 108.80 |
| **Site 3 -** Watershed Z | 281 | 247 | 226 | 136 | 136 | 1450 | 205.20 |
| **Site 4 -** Watershed P, Q | 155 | 514 | 103 | 164 | 120 | 5250 | 211.20 |
| **Site 5 -** Watershed BB, R | 174 | 190 | 376 | 152 | 546 | 3015 | 287.60 |
| **Site 6 -** Watershed DD | 175 | 131 | 181 | 205 | 155 | 1535 | 169.40 |
| **Site 7 -** Watersheds A, C, F | 124 | 72 | 137 | 80 | 91 | 5140 | 100.80 |
| **Site 8 -** Watershed B, D | 146 | 40 | 98 | 146 | 103 | 7205 | 106.60 |
| **Site 9 -** Watershed E, G | 64 | 74 | 112 | 48 | 61 | 6010 | 71.80 |
| **Site 10 -** Watershed H | 237 | 79 | 241 | 255 | 187 | 3075 | 199.80 |
| **Site 11 -** Watershed H | 822 | 2 | 889 | 421 | 106 | 2260 | 448.00 |
| **Site 12 -** Watershed I | 441 | 184 | 128 | 327 | 516 | 11250 | 319.20 |
| **Site 13 -** Watershed I | 48 | 155 | 65 | 210 | 52 | 10700 | 106.00 |
| **Site 14 -** Watershed F | 403 | 1353 | 285 | 187 | 208 | 2115 | 487.20 |
| **Site 15 -** Watershed AA | 110 | 223 | 125 | 75 | 120 | 6750 | 130.60 |
| **Site 16 -** Watershed S | 382 | 133 | 169 | 68 | 98 | 4450 | 170.00 |
| **Site 17 -** Watershed S | 269 | 117 | 31 | 243 | 399 | 775 | 211.80 |
| **Site 18 -** Watershed W | 152 | 123 | 295 | 228 | 112 | 6075 | 182.00 |
| **Site 19 -** Watershed U, V | 161 | 225 | 155 | 89 | 35 | 2010 | 133.00 |
| **Site 20 -** Watershed G | 902 | 483 | 83 | 327 | 38 | 210 | 366.60 |
| **Site 21 -** Watershed L, J | 228 | 209 | 256 | 47 | 87 | 1885 | 165.40 |
| **Site 22 -** Watershed T | 43 | 380 | 132 | 46 | 180 | 3035 | 156.20 |
| **Site 23 -** Watershed O | 230 | 290 | 310 | 122 | 103 | 13500 | 211.00 |
| **Site 24 -** Watershed K, M, N | 406 | 169 | 73 | 336 | 71 | 5555 | 211.00 |
| **Overall** | 260.75 | 250.17 | 211.71 | 178.21 | 157.21 | 107735 | 211.61 |

The Indiana Water Pollution Control Board (327 IAC 2-1-6 Section 6(d)) set forth water quality targets for *E. coli* for any one sample in a 30-day period. Concentrations for a one-time *E. coli* sample are not to exceed 235 cfu/100 ml. Data in Table 15 was collected as one sample in a 30-day period and concentrations are not to exceed 235cfu/mL. The Indiana Water Pollution Control Board also set forth water quality targets for *E. coli* that are not to exceed concentrations greater than 125 cfu/100 ml as a geometric mean based on no less than five samples spaced equally over a 30-day period (327 IAC 2-1-6 Section 6(d)). Table 16 shows *E. coli* data collected by IDEM using five samples equally spaced over 30-days. The geometric mean of these samples must not exceed 125 cfu/100mL concentration sampling. This data was collected by IDEM for the purpose of investigating if any currently listed segments could be removed from the 303d list. Several of the IDEM *E. coli* sample sites (22) overlapped the sample sites of this project. IDEM sample sites 17-30 all exceeded the State's geometric mean standard for *E. coli*.

**Table 16: *E. coli* - IDEM**

| *E. coli* cfu/100mL – IDEM Sampling | | | | | | |
|---|---|---|---|---|---|---|
| | **10/1/07** | **10/9/07** | **10/15/07** | **10/22/07** | **10/29/07** | |
| | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | GeoMean |
| **Site 1 -** Watershed X, Y | 12 | 82 | 17.3 | 40.4 | 21.3 | 27.1 |
| **Site 2 -** Watershed CC | 72.7 | 77.6 | 13.2 | 38.2 | 6.3 | 28.2 |
| **Site 3 -** Watershed Z | 23.3 | 40.8 | 75.4 | 29.8 | 14.5 | 31.5 |
| **Site 4 -** Watershed P, Q | 16.6 | 29.2 | 78.4 | 38.2 | 50.4 | 37.4 |
| **Site 5 -** Watershed BB, R | 57.6 | 48.7 | 50.4 | 75.4 | 16 | 44.3 |
| **Site 6 -** Watershed DD | 365.4 | 25.9 | 6.3 | 108.6 | 81.3 | 55.5 |
| **Site 7 -** Watersheds A, C, F | 74.9 | 77.1 | 46.5 | 88.4 | 33.6 | 60.3 |
| **Site 8 -** Watershed B, D | 36.8 | 104.3 | 72.3 | 64.4 | 95.9 | 70.3 |
| **Site 9 -** Watershed E, G | 108.1 | 160.7 | 70.8 | 71.2 | 19.7 | 70.4 |
| **Site 12 -** Watershed I | 96 | 55.4 | 66.3 | 117.8 | 49.6 | 72.9 |
| **Site 13 -** Watershed I | 109.2 | 84.2 | 57.6 | 74.9 | 121.1 | 86.4 |
| **Site 14 -** Watershed F | 79.4 | 198.9 | 231 | 88.4 | 44.1 | 107.3 |
| **Site 15 -** Watershed AA | 238.2 | 149.7 | 261.3 | 146.7 | 16.7 | 117.9 |
| **Site 16 -** Watershed S | 167.4 | 209.8 | 172.3 | 82 | 58.1 | 123.6 |
| **Site 17 -** Watershed S | 2419.2 | 111.2 | 41.3 | 185 | 20.3 | 133.1 |
| **Site 18 -** Watershed W | 127.4 | 178.5 | 325.5 | 101.7 | 57.3 | 134.0 |
| **Site 19 -** Watershed U, V | 133.3 | 290.9 | 461.1 | 101.7 | 30.5 | 140.9 |
| **Site 20 -** Watershed G | 218.7 | 248.9 | 69.7 | 248.9 | 77.1 | 148.7 |
| **Site 21 -** Watershed L, J | 26.5 | 1553.1 | 82 | 22.8 | 980.4 | 149.8 |
| **Site 22 -** Watershed T | 307.6 | 285.1 | 95.8 | 222.4 | 101 | 180.0 |
| **Site 23 -** Watershed O | 613.1 | 275.5 | 325.5 | 135.4 | 26.2 | 181.1 |
| **Site 24 -** Watershed K, M, N | 686.7 | 143.9 | 290.9 | 172.3 | 66.3 | 201.0 |
| **Site 25 –** Watershed H | 290.9 | 156.5 | 313 | 410.6 | 121.1 | 234.5 |
| **Site 26 –** Watershed C | 137.4 | 816.4 | 325.5 | 218.7 | 106.7 | 243.3 |
| **Site 27 –** Watershed D | 248.1 | 365.4 | 579.4 | 224.7 | 77.1 | 246.5 |
| **Site 28 –** Watershed V | 1732.9 | 648.8 | 48 | 124.6 | 307.6 | 290.5 |
| **Site 29 –** Watershed E | 613.1 | 727 | 547.5 | 435.2 | 154.1 | 439.3 |
| **Site 30 –** Watershed N | 1119.9 | 410.6 | 1119.9 | 488.4 | 109.5 | 487.5 |

### 5.3.8 Other Parameters

In addition to the sampling of dissolved oxygen, nitrates, total phosphorus, total suspended solids, biochemical oxygen demand, and *E. coli,* other in-situ parameters such as pH, conductivity, and temperature readings were also taken at each sampling event.

pH is estimated by the concentration of $H^+$ ions present in a solution. Aquatic organisms are sensitive to pH, so it is therefore an important measurement of water quality. A range of 6.5 to 8.2 is best for most aquatic organisms. pH for Big Walnut Creek and its tributaries did not fall outside of this optimal range.

Conductivity is the ability of a solution to carry an electrical current. The presence of ions allows a current to be carried. Conductivity is higher in low or base flow conditions since water moves more slowly across soils and substrates that contain ions. Other ions also dissolve easier into slower moving water which increases conductivity levels.

Temperature is an important indicator of overall water quality. Temperature affects dissolved oxygen, photosynthesis, and metabolism of aquatic organisms. Aquatic life in Indiana streams are protected by the Indiana Administrative Code (IAC) (327 IAC 2-1-6). The code sets maximum water temperature limits in order to protect aquatic life for Indiana streams. For example, stream temperatures during the months of June, July, August, and September should not exceed 90°F (23.7°C) by more than 1% of the hours in a twelve month period. And at no time should a waters temperature exceed this same maximum limit by more than 3°F (1.7°C). Several of the sample sites were above the 90°F temperature during the time of sampling in the months of May, July, and August 2007, and June 2008. It is not know if the sites exceeded 90°F by more than 1% of the hours in 12 month period. One site did exceed the maximum limit of 90°F at any one time by 3°F.

### 5.3.9 Biological Data – Aquatic Macroinvertebrates

Biological data in the form of macroinvertebrate analysis was conducted twice as part of this project. Sampling efforts resulted in collecting 50 different macroinvertebrate genera during the spring collection and 65 genera during the fall collection. Dominant species collected during the spring and fall differed among the seasons. The spring dominant species included midges (Chironomidae), blackfly larvae (Simuliidae), and riffle beetles (primarily *Stenelmis*). Fall dominant species included caddisflies (Trichoptera), mayflies (Ephemeroptera) and midges (Chironomidae). The sediment-tolerant midge *Orthocladius obumbratus* was common amongst many of the sites at both spring and fall collections. An uncommon caddisfly (*Helicopsyche borealis*) was abundant during the fall collection sample at Miller Creek (Site 12).

Bioassessment of macroinvertebrates can indicate impairment of sites, while the organisms present at the site can indicate what type of impairment is present. Poor habitat quality can be one type of impairment that affects aquatic life. Figure 1a of the Aquatic Macroinvertebrate Report (Appendix F) shows the relationship between the mean Ohio EPA bioassessment score and QHEI habitat scores. The correlation between habitat and the bioassessment score should be within ten percent of the expected score in order to rule out low biological scores due to habitat impairments. If the biological score is low in the presence of good habitat, then water quality problems are suspected.

There are two sites that fall farthest from the expected scores. They are Limestone Creek (Site 22) and Jones Creek (Site 17). Both sites had good QHEI scores, but low biotic index scores. There was a low diversity of the organisms that were collected at these sites. Low diversity in the presence of good habitat indicates a water quality concern at these locations.

Due to an overall a lack of biotic integrity, four other sites are also of concern based on macroinvertebrate sampling. These are mainstem Sites 7 and 8, Site 10, and Site 24. In addition to these four sites, the headwaters of the watershed are also of interest since both biotic index and habitat scores are low. In this general location the macroinvertebrate analysis proves to be a limited diagnostic tool, since habitat impairments dictate low diversity, regardless of pollution levels. Therefore, we are uncertain, based on invertebrates, exactly how impaired the water quality may be due to pollution.

The Big Walnut Watershed has overall good to excellent habitat for aquatic life. The biggest concerns to habitat for aquatic life are lack of riparian vegetation and stream bank erosion. Nutrient enrichment also appears to be a problem in several locations based on the composition of species present. The complete Aquatic Macroinvertebrate Report can be referenced in Appendix F.

# 6.0 LAND USE

## 6.1 Land Use Composition by Subwatersheds

Land use in the Big Walnut Watershed is mostly rural or agricultural (Figure U1). Figures U2-U20 (Appendix A) show land use at a more usable scale for each priority 14-HUC subwatershed. The land use layer that was referenced was generated from the Central Indiana Water Resources Partnership (CIWRP) Pilot Studies by Indiana University-Purdue University Indianapolis Center for Earth and Environmental Science and Center for Urban Policy and the Environment (IUPUI-CEES and CUPE) (J. Wilson) 2003. The predominant land use is agriculture. Other major land use types within the watershed include forest and grasslands/suburban land. Residential/urban areas would compose a majority of the remaining land use. Table 17 defines acreage and percentages of each land use within the Big Walnut Watershed on an individual 14-HUC watershed level. For the most part, when looking at land use across the subwatersheds, percent of each subwatershed in a particular land use was considered more heavily than total acreage of a given land use. Since the water quality sampling strategy generally links water quality findings to a given subwatershed, it is more important to consider the land use characteristics of that subwatershed rather than total acreage when trying to understand the various land use influences.

### 6.1.1 Agricultural

With agriculture dominating the majority of the land use, many of the subwatersheds have similar acreages/percentages of such land use. Subwatersheds with greater than 70% of their acreage in active agricultural production include Subwatersheds J, P, Q, R, X, Y, Z, BB, and CC. Several of these subwatersheds are clustered in certain areas of the larger watershed. These areas can be generally described as the headwaters areas of Big Walnut Creek in Boone and Hendricks Counties, as well as the headwaters area of Deer Creek in Hendricks and Putnam County.

### 6.1.2 Forested

In general, forested land use increases in the southern portion of the watershed. Subwatersheds with the greatest percentages of forested land use include Subwatersheds C, E, G, K, M, V, and W. Most notable are Subwatersheds E and G (the most southern end of the mainstem of Big Walnut Creek and K (the most southern end of Deer Creek where Deer Creek enters Big Walnut Creek). The forested land use in these areas is clearly associated with steeper terrain and topography in this portion of the watershed. The local terrain and soils do not lend themselves to agricultural land use.

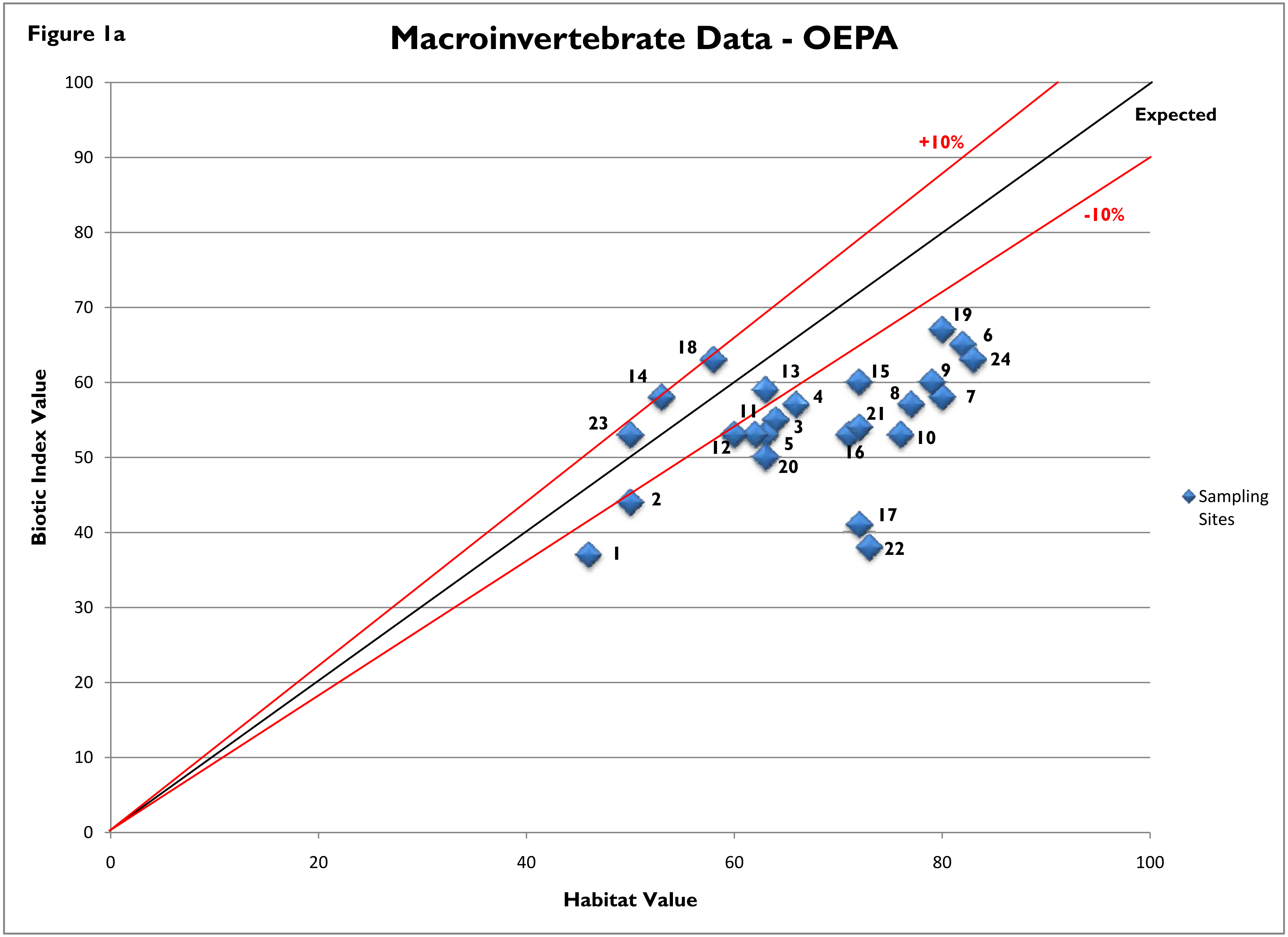


Figure 1a
Macroinvertebrate Data - OEPA
Biotic Index Value
Habitat Value
Expected
+10%
-10%
Sampling Sites
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
1
2
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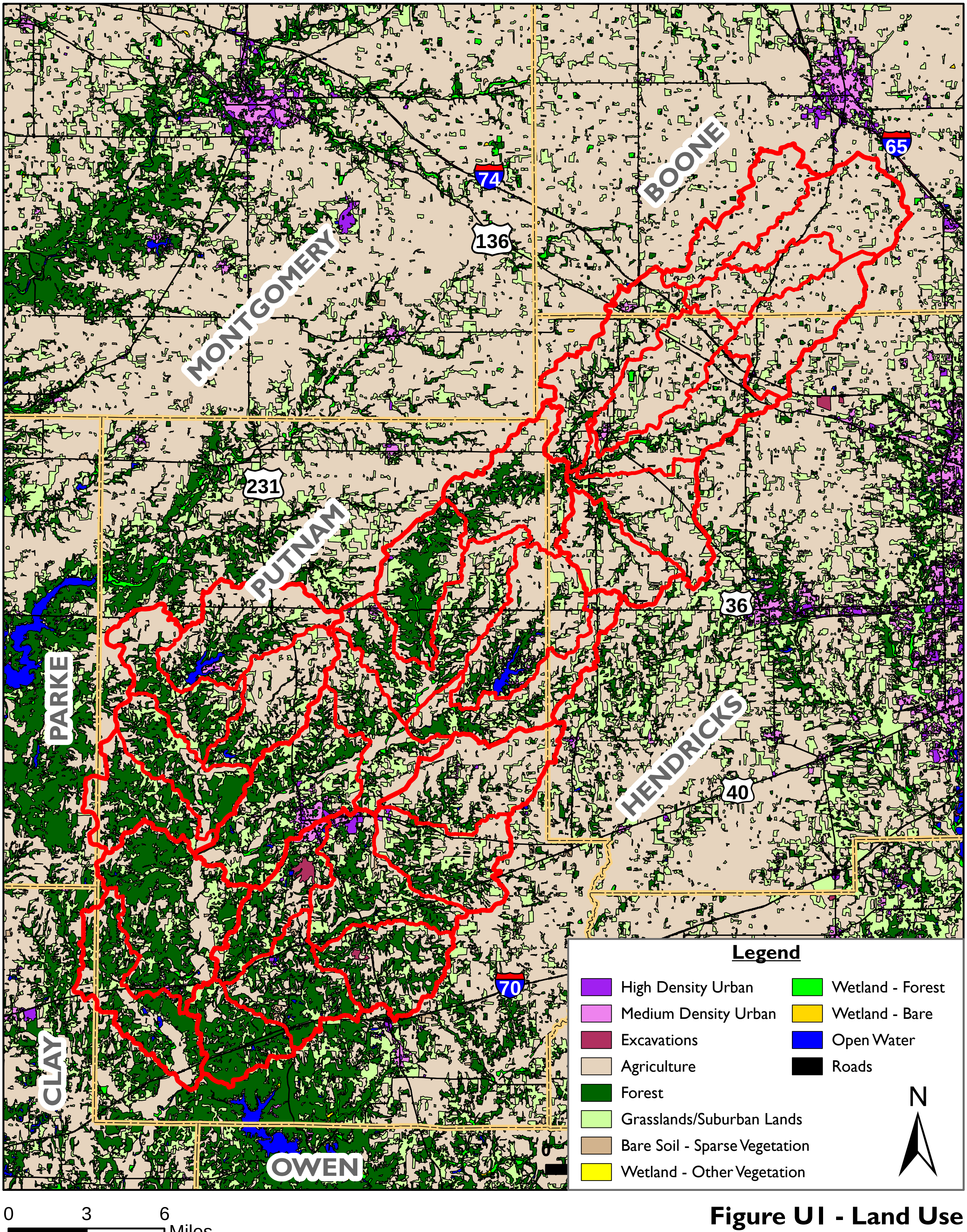



**Figure U1 - Land Use**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

| Table 17: Land Use | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Subwatersheds | | Watershed Acreage | Acres of Agriculture | Percent Agriculture | Acres of Forest | Percent Forest | Acres of High Density Urban | Percent High Density Urban |
| A | Big Walnut Creek - Barnard | 10027 | 6249.32 | 62.32% | 2051.61 | 20.46% | 0.00 | 0.00% |
| B | Big Walnut Creek - Dry Branch | 8145 | 4360.21 | 53.53% | 1389.16 | 17.06% | 24.73 | 0.30% |
| C | Big Walnut Creek - Ernie Pyle Memorial Highway | 8417 | 2714.11 | 32.25% | 3476.97 | 41.31% | 17.04 | 0.20% |
| D | Big Walnut Creek - Greencastle | 14170 | 4020.17 | 28.37% | 4336.05 | 30.60% | 187.13 | 1.32% |
| E | Big Walnut Creek - Johnson Branch | 9462 | 3125.95 | 33.04% | 4184.78 | 44.23% | 9.36 | 0.10% |
| F | Big Walnut Creek - Plum Creek/Bledsoe Branch | 12122 | 6050.71 | 49.92% | 2637.92 | 21.76% | 21.48 | 0.18% |
| G | Big Walnut Creek - Snake Creek/Maiden Run | 15537 | 4068.31 | 26.18% | 7620.56 | 49.05% | 8.70 | 0.06% |
| H | Clear Creek Headwaters (Putnam) | 11125 | 6348.07 | 57.06% | 1681.67 | 15.12% | 13.08 | 0.12% |
| I | Clear Creek - Miller Creek | 8778 | 5062.25 | 57.67% | 1480.80 | 16.87% | 17.49 | 0.20% |
| J | Deer Creek Headwaters (Putnam) | 10573 | 7406.24 | 70.05% | 1141.33 | 10.79% | 18.91 | 0.18% |
| K | Deer Creek - Leatherwood Creek | 5852 | 708.05 | 12.10% | 3724.92 | 63.65% | 0.00 | 0.00% |
| L | Deer Creek - Little Deer Creek | 8798 | 4198.31 | 47.72% | 1801.51 | 20.48% | 80.45 | 0.91% |
| M | Deer Creek - Mosquito Creek | 8094 | 2205.75 | 27.25% | 3548.30 | 43.84% | 61.52 | 0.76% |
| N | Deer Creek - Owl Branch | 9727 | 2920.66 | 30.03% | 3036.53 | 31.22% | 279.68 | 2.88% |
| O | Deweese Creek | 7006 | 1771.74 | 25.29% | 2254.57 | 32.18% | 72.81 | 1.04% |
| P | East Fork Big Walnut Creek - Lower | 8909 | 6295.25 | 70.66% | 723.43 | 8.12% | 12.25 | 0.14% |
| Q | East Fork Big Walnut Creek - Ross Ditch | 8975 | 7733.63 | 86.17% | 201.17 | 2.24% | 10.51 | 0.12% |
| R | Hunt Creek | 6880 | 5103.54 | 74.18% | 535.64 | 7.79% | 0.00 | 0.00% |
| S | Jones Creek | 8704 | 5106.92 | 58.67% | 1291.30 | 14.84% | 0.00 | 0.00% |
| T | Limestone Creek | 8366 | 3247.13 | 38.81% | 2929.24 | 35.01% | 23.55 | 0.28% |
| U | Little Walnut Creek - Headwaters | 7780 | 3436.25 | 44.17% | 2233.96 | 28.71% | 0.00 | 0.00% |
| V | Little Walnut Creek - Leatherman Creek | 7303 | 2178.18 | 29.83% | 3372.25 | 46.18% | 0.00 | 0.00% |
| W | Little Walnut Creek - Long Branch | 6991 | 2318.59 | 33.17% | 3103.23 | 44.39% | 0.00 | 0.00% |
| X | Main Edlin Ditch - Grassy Branch | 5622 | 4906.08 | 87.27% | 54.26 | 0.97% | 3.81 | 0.07% |
| Y | Main Edlin Ditch - Smith Ditch | 9377 | 8584.39 | 91.55% | 110.45 | 1.18% | 0.00 | 0.00% |
| Z | Middle Fork Big Walnut Creek | 8681 | 6576.4 | 75.76% | 216.71 | 2.50% | 14.42 | 0.17% |
| AA | Owl Creek | 10343 | 5590.94 | 54.06% | 2089.77 | 20.20% | 9.20 | 0.09% |
| BB | Ramp Run - East Fork Outlet | 8219 | 6082.55 | 74.01% | 559.66 | 6.81% | 0.00 | 0.00% |
| CC | West Fork Big Walnut Creek Headwaters | 7065 | 6459.83 | 91.43% | 47.70 | 0.68% | 0.00 | 0.00% |
| DD | West Fork Big Walnut Creek - Lower | 10107 | 6756.92 | 66.85% | 923.01 | 9.13% | 5.59 | 0.06% |
| | Totals | 271155 | 141586.45 | 52.22% | 62758.46 | 23.14% | 891.71 | 0.33% |

| Table 17: Land Use (cont) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Subwatersheds | | Acres of Medium Density Urban | Percent Medium Density Urban | Acres of Grasslands/ Suburban Lands | Percent Grasslands/Suburban Lands | Acres of Excavation | Percentage Excavation |
| A | Big Walnut Creek - Barnard | 0.00 | 0.00% | 1516.15 | 15.12% | 0.00 | 0.00% |
| B | Big Walnut Creek - Dry Branch | 1.67 | 0.02% | 2256.26 | 27.70% | 0.00 | 0.00% |
| C | Big Walnut Creek - Ernie Pyle Memorial Highway | 22.41 | 0.27% | 1904.68 | 22.63% | 0.00 | 0.00% |
| D | Big Walnut Creek - Greencastle | 634.93 | 4.48% | 4695.70 | 33.14% | 0.00 | 0.00% |
| E | Big Walnut Creek - Johnson Branch | 13.38 | 0.14% | 1884.95 | 19.92% | 0.67 | 0.01% |
| F | Big Walnut Creek - Plum Creek/Bledsoe Branch | 114.24 | 0.94% | 3087.19 | 25.47% | 0.00 | 0.00% |
| G | Big Walnut Creek - Snake Creek/Maiden Run | 78.59 | 0.51% | 3497.94 | 22.51% | 0.00 | 0.00% |
| H | Clear Creek Headwaters (Putnam) | 344.32 | 3.10% | 2246.72 | 20.20% | 0.00 | 0.00% |
| I | Clear Creek - Miller Creek | 17.24 | 0.20% | 2079.20 | 23.69% | 2.97 | 0.03% |
| J | Deer Creek Headwaters (Putnam) | 61.24 | 0.58% | 1855.63 | 17.55% | 0.00 | 0.00% |
| K | Deer Creek - Leatherwood Creek | 5.93 | 0.10% | 1235.78 | 21.12% | 0.60 | 0.01% |
| L | Deer Creek - Little Deer Creek | 9.46 | 0.11% | 2556.40 | 29.06% | 6.21 | 0.07% |
| M | Deer Creek - Mosquito Creek | 40.90 | 0.51% | 1911.60 | 23.62% | 13.71 | 0.17% |
| N | Deer Creek - Owl Branch | 172.85 | 1.78% | 3025.46 | 31.10% | 15.59 | 0.16% |
| O | Deweese Creek | 378.35 | 5.40% | 2064.77 | 29.47% | 334.58 | 4.78% |
| P | East Fork Big Walnut Creek - Lower | 25.44 | 0.29% | 15.92 | 0.18% | 28.78 | 0.32% |
| Q | East Fork Big Walnut Creek - Ross Ditch | 32.69 | 0.36% | 864.46 | 9.63% | 2.10 | 0.02% |
| R | Hunt Creek | 0.00 | 0.00% | 1113.69 | 16.19% | 0.00 | 0.00% |
| S | Jones Creek | 2.29 | 0.03% | 2099.53 | 24.12% | 0.00 | 0.00% |
| T | Limestone Creek | 1.99 | 0.02% | 1950.26 | 23.31% | 85.91 | 1.03% |
| U | Little Walnut Creek - Headwaters | 0.00 | 0.00% | 2026.72 | 26.05% | 0.00 | 0.00% |
| V | Little Walnut Creek - Leatherman Creek | 0.00 | 0.00% | 1659.68 | 22.73% | 0.00 | 0.00% |
| W | Little Walnut Creek - Long Branch | 0.00 | 0.00% | 1524.70 | 21.81% | 0.00 | 0.00% |
| X | Main Edlin Ditch - Grassy Branch | 0.00 | 0.00% | 643.28 | 11.44% | 0.00 | 0.00% |
| Y | Main Edlin Ditch - Smith Ditch | 0.00 | 0.00% | 597.07 | 6.37% | 3.12 | 0.03% |
| Z | Middle Fork Big Walnut Creek | 88.07 | 1.01% | 1534.22 | 17.67% | 22.56 | 0.26% |
| AA | Owl Creek | 105.51 | 1.02% | 2027.68 | 19.60% | 4.46 | 0.04% |
| BB | Ramp Run - East Fork Outlet | 0.00 | 0.00% | 1533.32 | 18.66% | 0.00 | 0.00% |
| CC | West Fork Big Walnut Creek Headwaters | 0.00 | 0.00% | 539.43 | 7.64% | 0.00 | 0.00% |
| DD | West Fork Big Walnut Creek - Lower | 121.58 | 1.20% | 1997.19 | 19.76% | 11.77 | 0.12% |
| | Totals | 2273.08 | 0.84% | 55945.58 | 20.63% | 533.03 | 0.20% |

### 6.1.3 Residential/Urban

The watershed area in general does not contain much impervious area. Areas with extensive impervious land cover have been shown to undergo degradation in water quality and the ability to support biotic stream life. For the purposes of considering water quality impacts associated with impervious area, percent land use in high-density residential and medium-density residential categories were used as surrogate indicators of areas with higher impervious surface. It is important to note that comparisons of acreages in each land use category is a relative comparison among other subwatersheds in the Big Walnut project area, not that acreages or percentages that are labeled or discussed as 'large' or 'high' are actually notably so when compared across the state or to other communities.

Subwatersheds with relatively larger percentages of high-density residential land use include Subwatershed D, L, and N. All three of these areas are influenced by the City of Greencastle. Subwatersheds with high percentages of medium-density residential land use include some of those mentioned above associated with Greencastle (Subwatersheds D and N), as well as Subwatersheds H, O, Z, and AA. These subwatersheds are influenced by Heritage Lake, suburban growth southwest of Greencastle, north Salem in Hendricks County, and the Van Bibber mobile home community around Van Bibber/Glenn Flint Lake.

## 6.2 Riparian Habitat, Floodplains, and Wetland Soils

Watershed scientists have known for decades the critical role floodplains and wetlands play in overall water quality protection and quantity control. Floodplains, National Wetland Inventory (NWI) wetlands, and hydric soils, are shown in Figures F1-F21 (Appendix A) and summarized in Tables 1 and 2 (pgs 10 &13).

All of the subwatersheds have some acreage of wetlands, however, Subwatersheds H, AA, D, and G, all have greater than 25 acres of mixed wetland types within their boundaries. If the percentage of wetland acres is looked at none of the subwatersheds wetland acre percentage is greater than 0.40% of the total land acreage. Subwatershed C has the greatest acreage of forested wetland. Subwatershed C is part of the area along the Big Walnut Creek Corridor with much of the land protected in nature preserves and other forms of land conservation.

Several of the subwatersheds have high percentages of floodplain relative to their total acreage. Subwatersheds E, G, T, and X are some examples of subwatersheds like this. Subwatersheds with the most acres of floodplain include D, E, G, and H all with greater than 3000 acres of floodplain.

The subwatersheds in part or all of Boone County, Subwatersheds Q, X, Y, Z, CC, and DD, all have the greatest acreage and percentage of hydric soils. This is because the NRCS is currently reclassifying soils throughout the State of Indiana and Boone County was one of the first counties to be done. Most of the Subwatersheds in Putnam County will not have much hydric soil because of the topography of the county.

## 6.3 Agricultural Practices

Transect data collected by the Putnam County SWCD and NRCS was analyzed for the Putnam County portion of the Big Walnut Watershed. Information collected for transect data includes information such as present crop, previous crop, tillage practice, and several other items relating to soil.

The data analyzed shows 261 points within the watershed. Of the 261 points within the watershed, seven still show conventional tillage practices. No till practices show up as 180 of the points. The remaining points collected are either practices of mulch tillage, reduced tillage, or unknown/not applicable. Figure V shows the path of transect data collected for Putnam County.

Further conversation with the SWCD and NRCS personnel stated that most of the conventional tillage in Putnam County occurs in the northern part of the County, outside of the watershed. Subwatershed N, as well as the northern and western portions of Subwatersheds A and C are also areas where conventional tillage is still practiced, but these areas are not areas where transect data is collected.

In addition to transect data for Putnam County, data was received for Boone and Hendricks Counties as well. Boone County shows 67 points within the Big Walnut Creek Watershed. Of the 67 points, 16 points are no till practices. Conservation practices are represented as 28 of the points. The remaining 23 points are either practices of mulch tillage, reduced tillage, or unknown/not applicable. Hendricks County sampled 261 points within the Big Walnut Creek Watershed. Unfortunately, tillage information was not collected for the sample points.

## 6.4 Septic Areas & Sewer Utilities

Septic discharge is a concern of the county health departments of the Big Walnut Creek Watershed. This is because the majority of the homes in the watershed are in rural areas where sewer utilities are not available. The county health departments are working to help educate septic owners and installers on the proper do's and don'ts of septic systems.

The county health departments were contacted to find out if they were aware of septic system problems within the watershed. The Putnam County Health Department, who is currently working on a mapping septic system data into a GIS layer, noted several areas of concern. They have problems on a regular basis throughout the watershed. Areas with recent problems which have been repaired, or are in the process of being repaired include Ivanwald, Roachdale, Heritage Lake, and Morton. Their biggest problem areas are the Applewood Subdivision and the Van Bibber area.

The Boone County Health Department stated that the area of the county located in the Big Walnut Creek Watershed is a low diversity area and not much is known about septic concerns for that area.

The Boone County Health Department (BCHD) did provide information on a junkyard that was noted while driving the watersheds during windshield surveys. The junkyard is a well documented problem of Boone County. The junkyard has been the complaint of neighbors for many years. There have been several illegal open burning incidents, along with numerous permit and compliance violations. Violations are primarily focused on oil and tire storage and

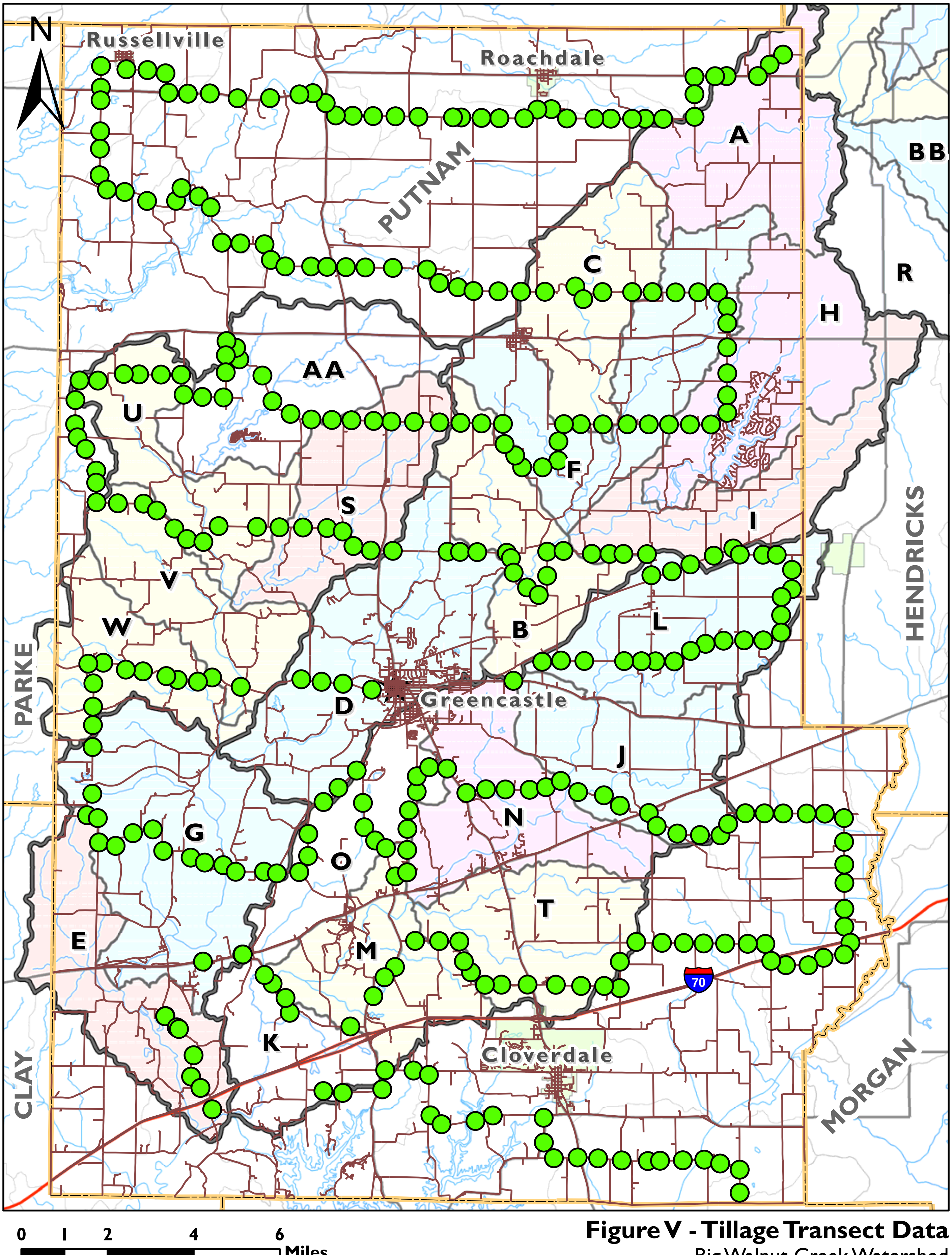



**Figure V - Tillage Transect Data**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

disposal. Numerous inspections to the site by IDEM and the BCHD have revealed pipes discharging to the adjacent ditch. Surface runoff and leaching are also believed to be problems. Petroleum waste is believed to be the biggest concern of contamination. The BCHD is continuously working with the owner to improve the conditions of the site.

The Hendricks County Health Department provided information stating that over 1000 of the septic systems within the Big Walnut Creek Watershed do not have documented records. Many of these systems are concentrated around the towns of North Salem, Lizton, and Jamestown. Septic systems with documentation are typically 20 years old or less. Several complaints have been received by the health department in scattered locations throughout the Hendricks County portion of the watershed.

### 6.5 Future Land Use

Putnam County is currently working on a new comprehensive plan for the county as the current plan is out of date. The majority of the land in Putnam County under the current plan remains unchanged. Proposed areas of development include residential, nature preserve, and commercial.

Zoning in Boone County within the area of the Big Walnut Watershed is predominantly general agriculture. Some county zoning is in place around the smaller towns such as Jamestown and New Brunswick. Zoning categories in these areas include low-density single-family residential, low-density single and two family residential, high-density multifamily residential, local business, general business, and light industry. Boone County is also currently updating their county comprehensive plan.

Hendricks County released their most current comprehensive plan in early 2007. Future land use for the area in which the Big Walnut Watershed is proposed as agricultural with some commercial development. Several small towns with mixed uses are located in these areas. Figures W1-W19 (Appendix A) illustrate land use via 2005 aerial photography within each priority 14-HUC watershed of the Big Walnut.

## 7.0 FIELD EVALUATIONS

### 7.1 Indiana Smallmouth Conservation Float Survey

On May 26th, 2007 a group of volunteers from the Indiana Smallmouth Conservation (ISC) surveyed a 15 mile portion of Big Walnut Creek by canoeing and kayaking the creek. The trip was from US 36 east of Bainbridge south to county road 100S southwest of Greencastle. The group documented their trip by taking GPS points and photographs of areas of concern. Streambank erosion and lack of buffer on agricultural fields was the biggest issue found by the group. The group also noted areas of farm field erosion and field tile drains.

The ISC also surveyed a southern stretch of Big Walnut Creek over several weekends in October 2008. This section was from Greencastle to the southern portion of the watershed. The main purpose of this trip was to pinpoint logjams, severe agricultural erosion areas, and other areas where the heavy June rains caused major flooding damage to the landscape.

Appendix G shows several maps of the areas that the ISC group surveyed. It also includes a photo journal of some of the poor land use practices and deteriorated areas.

## 7.2 Windshield Survey

Windshield surveys were conducted in all 30 14-digit HUC subwatersheds of the Big Walnut Watershed in early 2008. The surveys were conducted by driving all accessible roads in the watershed. The drives were performed with help from staff of the Boone, Hendricks, and Putnam County SWCDs. Large 24 inch by 36 inch maps of each individual 14-digit HUC watershed showing aerial photography, NWI features, and environmental issues were used as guides for the surveys.

The windshield surveys were carried out in order to gain a greater understanding of happenings within the Big Walnut Watershed. In addition, they were used to confirm items that GIS map layers illustrated and note items that were not visible using GIS. Items that were looked at during the surveys included, but were not limited to the following items:

- ✓ Confirmation of aerial land use categorization
- ✓ Field erosion/gullies
- ✓ Denuded pasture areas
- ✓ Livestock in or with access to streams
- ✓ Notable wet spots (wetland restoration sites and/or flooding concerns)
- ✓ Lack of buffers – farmed/mown to edge of streams
- ✓ No-till versus conventional tillage
- ✓ Bank erosion at stream crossings
- ✓ Culvert constriction at road crossings
- ✓ Buffer width
- ✓ Environmental site confirmation (open dumps, NPDES pips, CAFOs, etc.)
- ✓ Additional CFOs
- ✓ NWI confirmation

Handwritten notes and GPS points were recorded on the large field maps in locations where areas of concern were identified. These locations and findings were then incorporated into the project GIS. Photographs of streams and other locations were also taken to document some of the findings. Figure X shows all of the points where one or more of the above listed items were documented.

Concerns within the subwatersheds resulting from the windshield surveys were narrowed to the most common observations, namely livestock access to streams and lack of stream/ditch buffers. The other items on the list which were looked at had very few to no occurrences. The minimal number of occurrences of these issues also does not represent a significant water quality impacts on the Big Walnut Creek Watershed.

### 7.2.1 Buffers

Buffers are important to waterways as they work to filter nutrients and reduce sediment from entering the waterways. Buffers are effective at reducing pollutant loads if they are at least 25 feet from the top of bank; although, 70 feet is preferred/ideal, with a maximum typically of 100 feet. These widths are recommended by the NRCS, but vary by site. A simple rating system of 'very poorly buffered' and 'moderate to poorly buffered' was developed to gauge the relative condition or presence of buffers observed during the windshield survey. The 'moderate to poorly buffered' subwatersheds were defined as such when the number of observations of buffers less than 20 feet ranged from four to seven in a given subwatershed. 'Very poorly buffered' subwatersheds are those where the number of observations of buffers less than 20 feet was eight or more instances in the same subwatershed. 'Very poorly' or 'moderately to poorly' buffered subwatersheds were noted in 7 of the 30 subwatersheds (Figure Y).

***Very Poorly Buffered Subwatersheds – "Orange"***

Two of the subwatersheds, Main Edlin Ditch and Big Walnut Creek – Plum Creek, have high numbers of observations of little to no buffers.

- <u>Main Edlin Ditch – Smith Ditch </u>– Subwatershed Y
  This subwatershed is dominated by agricultural production. The majority of the fields are in conservation tillage; however, fields are worked and planted as close as possible to the edge of waterways.

- <u>Big Walnut Creek – Plum Creek/Bledsoe Branch</u> – Subwatershed F
  This subwatershed is primarily agricultural, but also has a high percentage of grassland/suburban land and forest. Most of the buffer problems in this subwatershed are associated with small tributaries that do not show up as blue lines on the maps.

***Moderately to Poorly Buffered Subwatersheds – "Blue"***

Five subwatersheds were observed to have a moderate number of instances of little to no buffer. Not surprisingly, some of the subwatersheds with moderate to poor buffers cluster together in the larger watershed. The moderate to poorly buffered subwatersheds all cluster around or near the very poorly buffered subwatersheds. All of the below watersheds have land uses that are primarily agriculture based. The buffer problems are a result of farming practices that come up to the edge of waterways.

- <u>Clear Creek – Headwaters (Putnam)</u> – Subwatershed H
- <u>Clear Creek – Miller Creek</u> – Subwatershed I
- <u>East Fork Big Walnut Creek – Ross Ditch – Subwatershed Q</u>
- <u>Main Edlin Ditch – Grassy Branch</u> – Subwatershed X
- <u>West Fork Big Walnut Creek – Headwaters</u> – Subwatershed CC

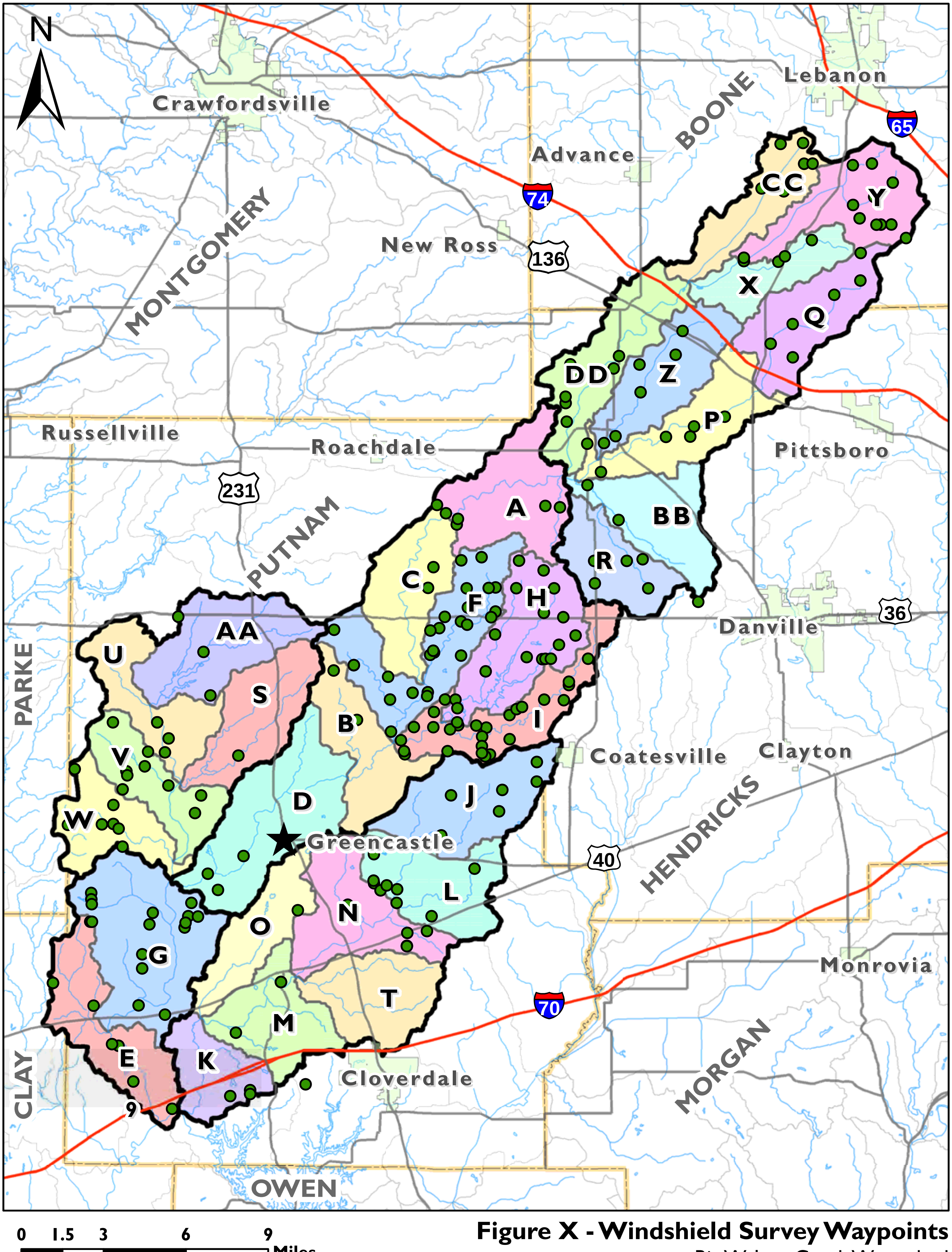



**Figure X - Windshield Survey Waypoints**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

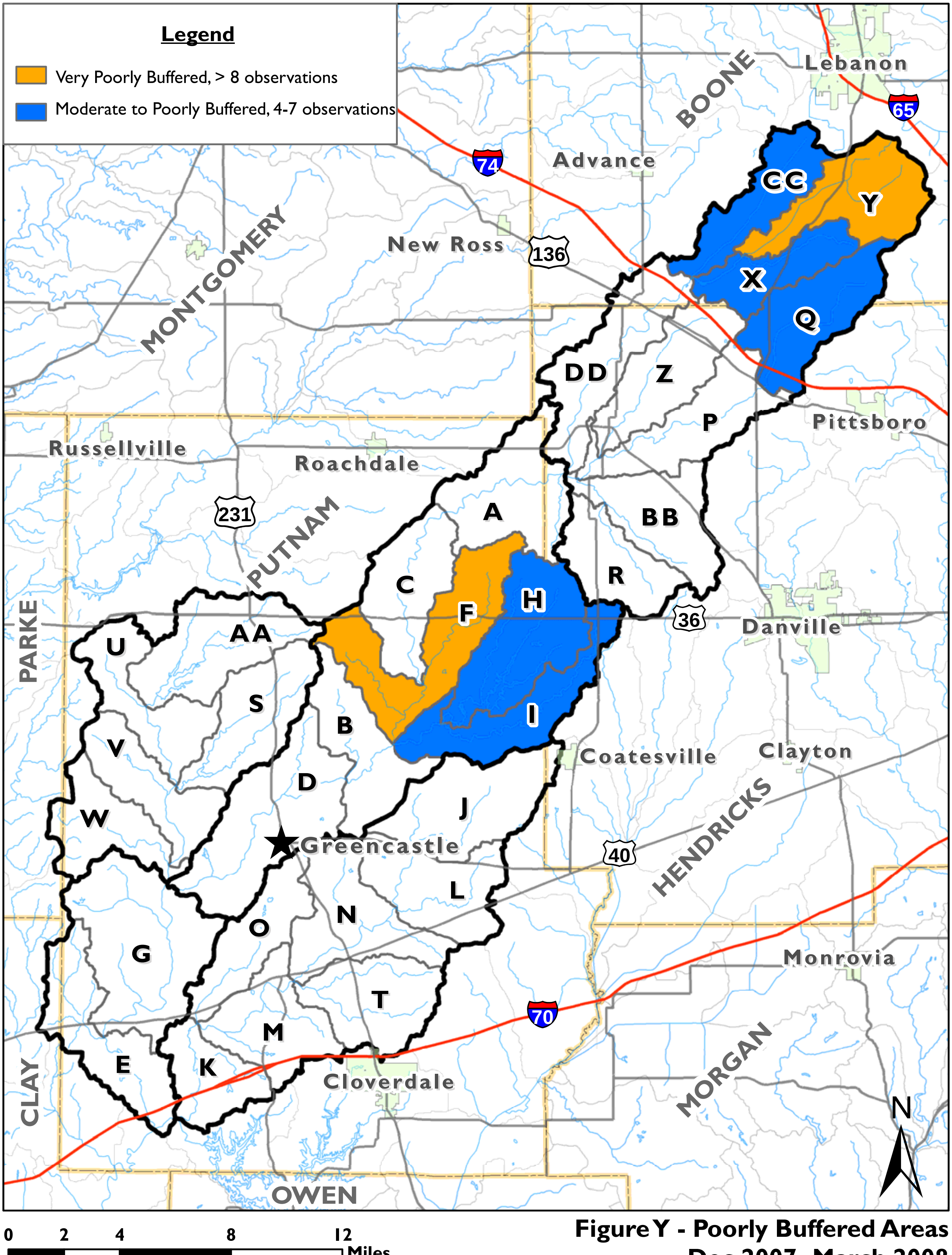



**Figure Y - Poorly Buffered Areas**
**Dec 2007- March 2008**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

### 7.2.2 Livestock Access to Streams

Livestock with access to streams have been documented as a concern because they deposit fecal material in or near streams making them potential source of *E. coli*. The livestock also walk over stream banks causing stream bank erosion and deposition of sediment into streams or increases in total suspended solids (TSS). Livestock in or with access to streams was noted in 27 of the 30 subwatersheds. A simple rating system of 'frequent' and 'moderate' was developed to gauge the relative frequency of livestock with access to streams. Six of the subwatersheds have 'frequent' numbers of observations (greater than eight) of livestock with access to streams. Eight of the subwatersheds have 'moderate' numbers of observations (greater than five but less than eight) (Figure Z). Figure Z also depicts the location of Confined Feeding Operations (CFOs) in each subwatershed. This environmental feature was included to assist in better understanding of livestock concentrations in the watershed relative to the locations where livestock were observed in the stream.

***Frequent Livestock in the Stream Subwatersheds – "Purple"***

- <u>Big Walnut Creek – Plum Creek/Bledsoe Branch</u> – Subwatershed F
- <u>Big Walnut Creek – Snake Creek/Maiden Run</u> – Subwatershed G
- <u>Clear Creek – Miller Creek</u> – Subwatershed I
- <u>Deer Creek – Little Deer Creek</u> – Subwatershed L
- <u>Deer Creek – Owl Branch</u> – Subwatershed N
- <u>West Fork Big Walnut Creek – Lower</u> – Subwatershed DD

These watersheds have a combined total of nine CFOs

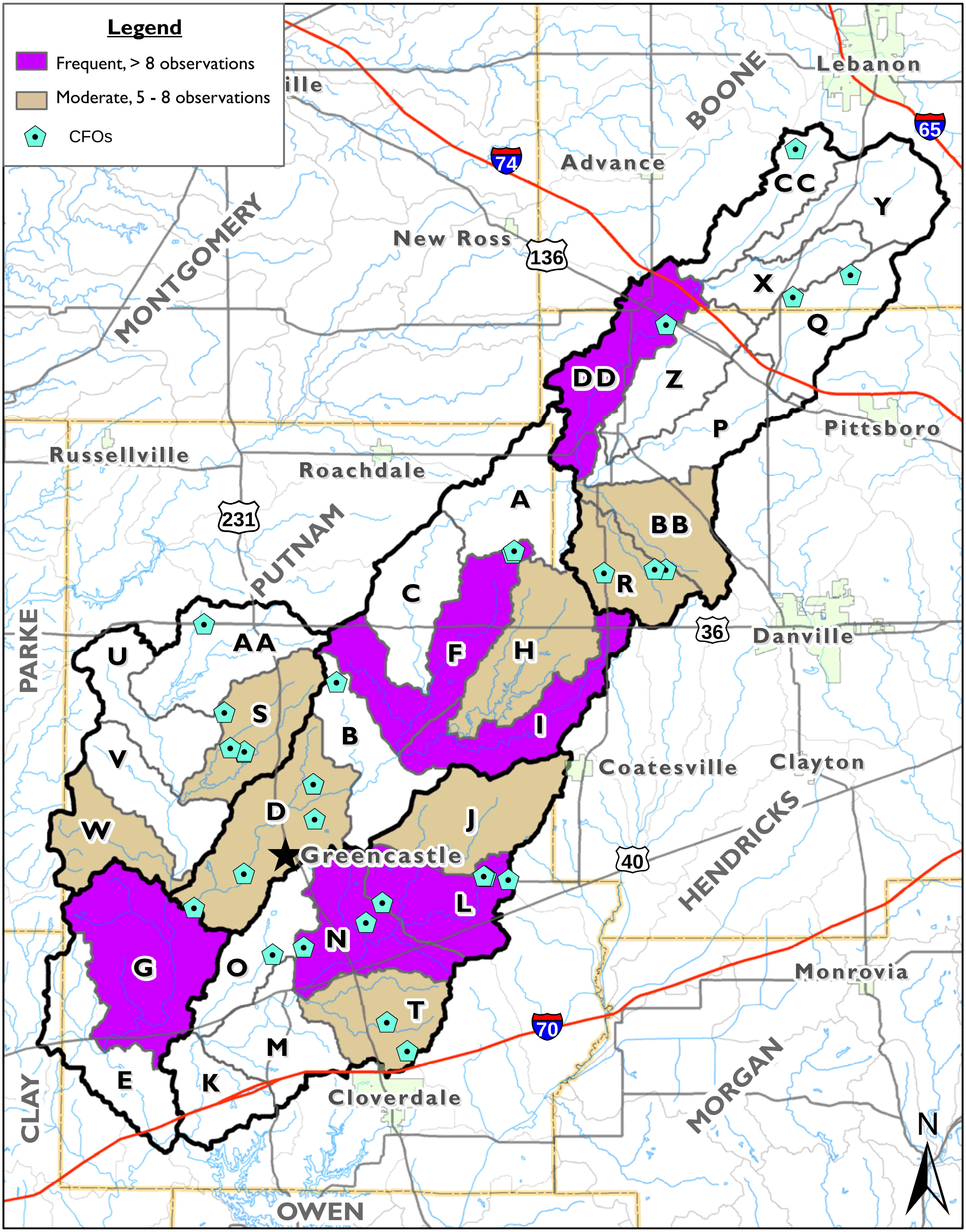
***Moderate to Frequent Livestock in the Stream Subwatersheds – "Tan"***

- <u>Big Walnut Creek – Greencastle</u> – Subwatershed D
- <u>Clear Creek – Headwaters (Putnam)</u> – Subwatershed H
- <u>Deer Creek – Headwaters</u> – Subwatershed J
- <u>Hunt Creek</u> – Subwatershed R
- <u>Jones Creek</u> – Subwatershed S
- <u>Limestone Creek</u> – Subwatershed T
- <u>Little Walnut Creek – Long Branch</u> – Subwatershed W
- <u>Ramp Run – East Fork Outlet</u> – Subwatershed BB

These watersheds have a combined total of thirteen CFOs

## 8.0 SELECTION OF CRITICAL AREAS (PRIORITY SUBWATERSHEDS)

A variety of criteria were used to develop Critical Areas (i.e. Priority Subwatersheds) in the larger watershed. Nutrient and sediment loads were calculated using concentration and flow data from each site for each of the sample sites on each sample date and then compared against values recognized by water quality professionals to be indicative of healthy conditions. In addition to relative load information, the subwatersheds were scored against information collected during windshield surveys such as lack of buffered streams present and cattle with access to the streams, as well as the presence of NPDES dischargers, significant water users,




0 2 4 8 12 Miles

**Figure Z - Livestock Access to Streams**
**Dec 2007- March 2008**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

and historic knowledge of Steering Committee members. Each subwatershed was listed in a spreadsheet and scored against twelve criteria based upon the aforementioned data (Table 18).

The original "1" and "2" scores (red and yellow coding) came from the relative impact that each subwatershed displayed for each parameter over the six sampling events (Shown as highlighted values in Tables 8-16). The Steering Committee then applied some discretion when reviewing the weighted scores by adjusting the importance of some parameters relative to others (e.g. double weighting the macroinvertebrate score since they are a more reliable long-term indicator than the individual chemical parameters). The scores for each subwatershed were totaled across the parameters to arrive at a total relative score. Subwatersheds associated with sample sites that showed elevated concentrations for multiple parameters, especially parameters that grossly exceeded state standards, targets, or were representative of multiple ecological concerns received a high score in the ranking table, those with a moderate concern, a low score, and those of little to no concerns were not given scores (Table 18). Since higher scored were assigned to higher concerns, those subwatershed with the highest total score (greater than nine) were identified as priority subwatershed for restoration and/or BMP implementation. In addition to the subwatersheds scoring nine or higher, some subwatersheds were also selected as priority watersheds based on concerns and knowledge of the Steering Committee. For example, Subwatershed O was selected as a 'moderate' (yellow) priority watershed because it was surrounded by four 'high' (red colored) priority Subwatersheds D, G, M, and N and implementing conservation practices with landowners in that area will likely require work in Subwatershed O. For the purposes of visual depiction and communication, the subwatersheds with highest concern (weighted score) were assigned a red status/color, while those with 'moderate' concern were assigned a "yellow" status/color. All remaining subwatersheds with lesser or limited concerns received no color. A final status/color distinction was made regarding subwatershed of exceptional quality and/or ecological function. These subwatersheds were colored green and will be further discussed in Section 8.2. A summary map showing the priority subwatersheds is represented in Figure AA.

The highest priority subwatersheds (shown in red on Figure W) and their individual parameters of concern include:

<u>Big Walnut Creek – Greencastle (Subwatershed D)</u>

Total Suspended Solids, *E. coli*, Total Phosphorus, Nitrate, Biochemical Oxygen Demand, Macroinvertebrates, Livestock in Streams, Confined Feeding Operations, NPDES Noncompliance, and Significant Water Users

<u>Big Walnut Creek – Snake Creek/Maiden Run (Subwatershed G)</u>

Total Suspended Solids, *E. coli*, Total Phosphorus, Nitrate, Biochemical Oxygen Demand, Livestock in Streams, and NPDES Noncompliance

<u>Clear Creek - Headwaters (Subwatershed H)</u>

Total Suspended Solids, *E. coli*, Dissolved Oxygen, Macroinvertebrates, Livestock in Streams, and NPDES Noncompliance

Clear Creek – Miller Creek (Subwatershed I)

Total Suspended Solids, *E. coli*, Total Phosphorus, Dissolved Oxygen, Biochemical Oxygen Demand, Livestock in Streams, and Buffers

Deer Creek – Mosquito Creek (Subwatershed M)

Total Suspended Solids, Total Phosphorus, Nitrate, Biochemical Oxygen Demand, Macroinvertebrates, and NPDES Noncompliance

Deer Creek – Owl Branch (Subwatershed N)

Total Suspended Solids, *E. coli*, Total Phosphorus, Nitrate, Biochemical Oxygen Demand, Macroinvertebrates, Livestock in Streams, and Confined Feeding Operations

West Fork Big Walnut Creek – Lower (Subwatershed DD)

Total Suspended Solids, Total Phosphorus, Nitrate, Biochemical Oxygen Demand, Livestock in Streams, Confined Feeding Operations, and NPDES Noncompliance

Subwatersheds ranked as ‘moderate’ priorities (shown in yellow on Figure AA) and their individual parameters of concern include:

Big Walnut Creek – Dry Branch (Subwatershed B)

Total Suspended Solids, Total Phosphorus, Nitrate, Biochemical Oxygen Demand, and Confined Feeding Operations

Deer Creek – Leatherwood Creek (Subwatershed K)

Total Suspended Solids, Total Phosphorus, Nitrate, Biochemical Oxygen Demand, and Macroinvertebrates

Deweese Creek (Subwatershed O)

*E. coli*, Confined Feeding Operations, NPDES Noncompliance, and Significant Water Users

Jones Creek (Subwatershed S)

Dissolved Oxygen, Macroinvertebrates, Livestock in Streams, and Confined Feeding Operations

Limestone Creek (Subwatershed T)

Total Suspended Solids, Dissolved Oxygen, Macroinvertebrates, Livestock in Streams, Confined Feeding Operations, NPDES Noncompliance, and Significant Water Users

Main Edlin Ditch – Grassy Branch (Subwatershed X)

Total Suspended Solids, *E. coli*, Nitrate, Macroinvertebrates, and Buffers

Main Edlin Ditch – Smith Ditch (Subwatershed Y)

Total Suspended Solids, *E. coli*, Nitrate, Macroinvertebrates, and Buffers

<u>Owl Creek (Subwatershed AA)</u>

Confined Feeding Operations, NPDES Noncompliance, and Significant Water Users

<u>West Fork Big Walnut Creek – Headwaters (Subwatershed CC)</u>

Dissolved Oxygen, Macroinvertebrates, Buffers, and Confined Feeding Operations

Finally, the remaining subwatersheds (shown without color on Figure AA) are considered, at this point, to be lower priorities from a water quality perspective. However, it is important to note that some areas shown in green have limited sample sites and therefore limited water quality data with which to draw conclusions. Even though these are lower priority subwatersheds areas it does not mean that protection of high quality land and other best management practices are not important in these areas.

## 8.1 Comparison with Dr. Gammon's Data

As part of the background investigation into historical Big Walnut Creek Watershed data, Dr. Gammon's macroinvertebrate and fish work was used to develop historical priority subwatersheds. These priority subwatersheds were assigned similar relative rankings and assigned the same red and yellow status/color system (i.e. 'red' representing those subwatersheds that are most impaired or degraded and therefore, high priorities). This historic summary of Dr. Gammon's work is based primarily on fish IBI while our priority subwatersheds are based on a combination of biological and chemical factors, as well as field observation. Figure BB shows these watershed priorities side-by-side with current subwatershed priorities.

From Figure BB, one can see that many of the critical subwatersheds that Dr. Gammon noted are the same ones that remain areas of concern today based on current and varied data. The current priority subwatersheds map includes more subwatersheds than Dr. Gammon's primarily because more factors were considered in the evaluation. Dr. Gammon's priority subwatersheds are all subwatersheds that current data reflects as having low QHEI scores. This comparison makes logical sense, as the criteria that make up the QHEI evaluation are parameters that denote favorable for fish habitat.

## 8.2 Additional Priority Subwatersheds

Analysis of the water quality monitoring data collected revealed an interesting, reoccurring circumstance along one particular segment of Big Walnut Creek. Between sample points 6 and 7, both along mainstem Big Walnut, there was a reduction in nutrient and sediment loads. Typically a nutrient and sediment load increase is expected as a stream flows downstream and picks up more drainage area and the influence of numerous tributaries. It is interesting to note that because of the work of IDNR-DNP, CILTI, and TNC, much of the land adjacent to Big Walnut between points 6 and 7 is in nature preserves or conservation easements. This area has notable, wide forested buffers, intact floodplains and some contiguous wetland. The important functional nature of this area for both water quality and habitat makes it a critical area to continue protecting and restoring. For this reason, Subwatersheds A, C, and F are also listed as priority subwatersheds (Figure AA). Figure CC shows priority Subwatersheds A, C, and F along with the nature preserves and conservation areas along the Big Walnut Creek Corridor that are currently being protected in addition to those lands that are priorities to be protected.

## Table 18: Watershed Priority Ranking

| Sub | TSS | E.coli | TP | Nitrate | DO | BOD | Macro-invertebrates | Livestock in Streams | Buffers | CFOs | NPDES Non-Compliance | Significant Water Users | Score | Subwatershed priority |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 1 | | | | | | | | | | | | 1 | A |
| B | 2 | | 2 | 2 | | 2 | | | | 1 | | | 9 | B |
| C | 1 | | | | | | | | | | 2 | | 3 | C |
| D | 2 | 1 | 2 | 2 | | 2 | 2 | 2 | | 2 | 2 | 1 | 18 | D |
| E | 2 | | 2 | 1 | | 2 | | | | | | 1 | 8 | E |
| F | 1 | 2 | | | | | 2 | 4 | 2 | 1 | | | 12 | F |
| G | 2 | 2 | 2 | 1 | | 2 | | 4 | | | 2 | | 15 | G |
| H | 1 | 6 | | | 2 | | 2 | 2 | 1 | | 1 | | 15 | H |
| I | 2 | 1 | 2 | | 2 | 1 | | 4 | 1 | | | | 13 | I |
| J | | | 1 | | | | | 2 | | | | | 3 | J |
| K | 2 | | 2 | 2 | | 2 | 2 | | | | | | 10 | K |
| L | | | 1 | | | | | 4 | | 2 | | | 7 | L |
| M | 2 | | 2 | 2 | | 2 | 2 | | | | 1 | | 11 | M |
| N | 2 | 2 | 2 | 2 | | 2 | 2 | 4 | | 1 | | | 17 | N |
| O | | 1 | | | | | | | | 1 | 2 | 1 | 5 | O |
| P | 1 | | 2 | 1 | | 1 | | | | | 2 | | 7 | P |
| Q | 1 | | 2 | 1 | | 1 | | | 1 | 1 | | | 7 | Q |
| R | | | | 1 | 1 | | | 2 | | | | | 4 | R |
| S | | | | | 2 | | 4 | 2 | | 2 | | | 10 | S |
| T | 1 | | | | 1 | | 4 | 2 | | 1 | 2 | 1 | 12 | T |
| U | 2 | 1 | 2 | 2 | | 1 | | | | | | | 8 | U |
| V | 2 | | 2 | 2 | | 1 | | | | | | | 7 | V |
| W | | | | | 1 | | | 2 | | | | | 3 | W |
| X | 1 | 1 | | 1 | | | 2 | | 1 | | | | 6 | X |
| Y | 1 | 1 | | 1 | | | 2 | | 2 | | | | 7 | Y |
| Z | | | | | | | | | | | 1 | 0.5 | 1.5 | Z |
| AA | | | | | | | | | | 1 | 1 | 0.5 | 2.5 | AA |
| BB | | | | 1 | 1 | | | 2 | | 1 | | | 5 | BB |
| CC | | | | | 2 | | 2 | | 1 | 1 | | | 6 | CC |
| DD | 2 | | 2 | 2 | | 2 | | 4 | | 1 | 1 | | 14 | DD |

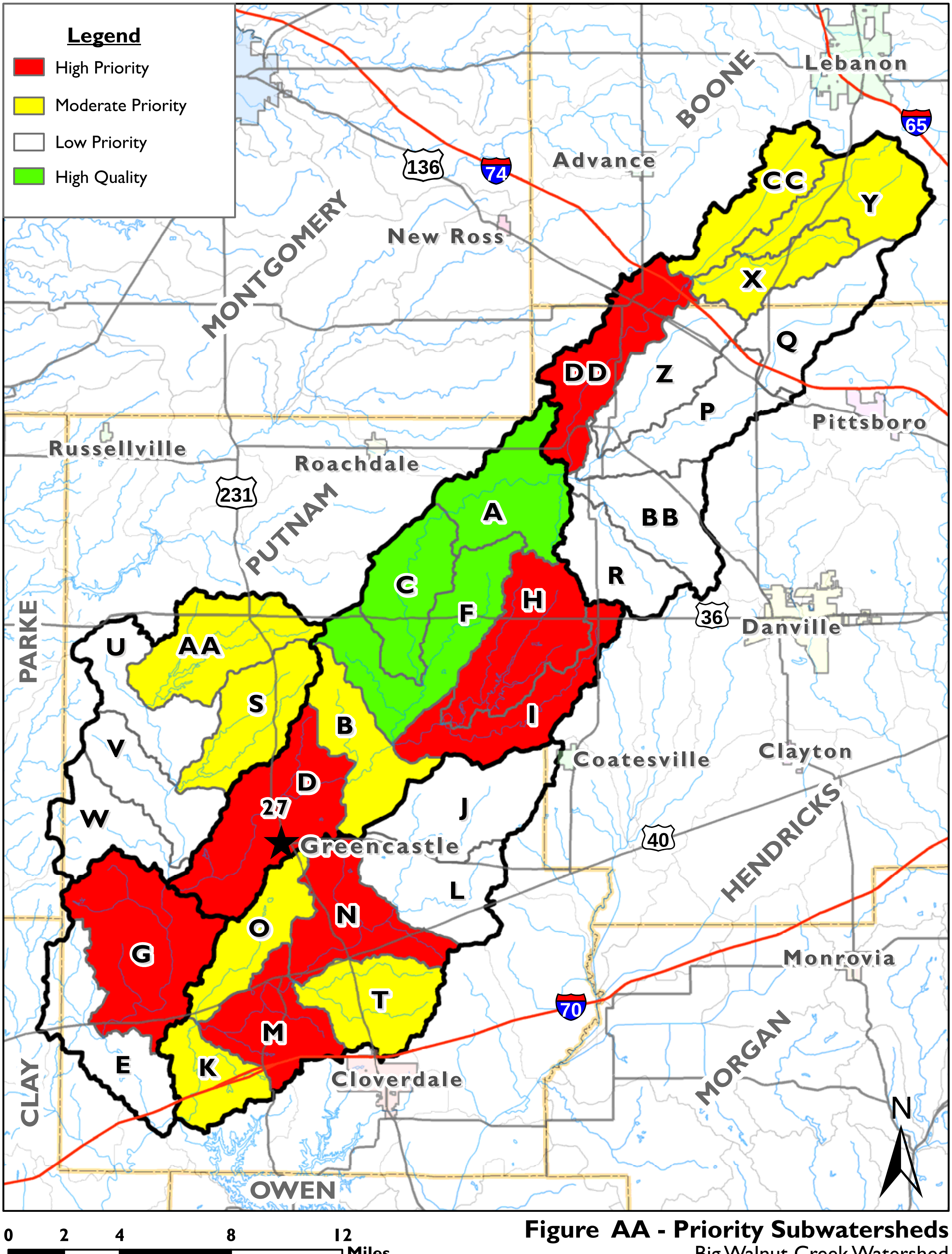



**Figure AA - Priority Subwatersheds**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

### 8.3 New HUC Boundaries for Priority Subwatersheds

In 2008 new watershed boundaries were released and implemented as standard nomenclature for State and Federal projects in Indiana. These new watershed definitions are on a 10-digit and 12-digit scale. The new boundaries are intended to replace the currently used 11-digit and 14-digit scale watersheds. With the release of these new boundaries, the priority subwatersheds for this project will slightly change. Instead of 16 of the 30 14-digit subwatershed being defined as priority subwatersheds, 9 of the new 15 12-digit scale subwatersheds will be considered priority subwatersheds for this project. This change is being shown in this plan only for the purpose of future grant funding. Subwatershed analysis will not be reevaluated for this plan on the 10 and 12-digit scale. The new subwatersheds are shown on Figure DD and are listed below.

- Town of Barnard – Big Walnut Creek (Subwatershed A1)
- Clear Creek (Subwatershed B1)
- Deweese Branch – Deer Creek (Subwatershed C1)
- Dry Branch – Big Walnut Creek (Subwatershed D1)
- Edlin Ditch (Subwatershed E1)
- Owl Creek (Subwatershed G1)
- Owl Branch (Subwatershed I1)
- Headwaters Little Walnut Creek (Subwatershed J1)
- Snake Creek – Big Walnut Creek (Subwatershed M1)
- Bledsoe Branch – Big Walnut Creek (Subwatershed N1)
- West Fork Big Walnut Creek (Subwatershed O1)

## 9.0 PUBLIC INPUT AND LOCAL CONCERNS

### 9.1 Stakeholders

An introductory public meeting was held on April 19th, 2007 at the Commissioner's Court in Greencastle, Indiana at 7 pm. Initial public concerns identified at this meeting included:

- Saving Soil
- Land use and practices in headwaters (Boone and Hendricks Counties)
- Economic Development (tax base for Bainbridge, Cloverdale, Greencastle)
- Flood Prevention – role of bridges, control structures, etc. Cost/benefit of structures
- Sedimentation (brown water)
- Growth rate and sewers – need for commercial growth
- Trail Connections (along streams, public access)
- Patterns of Flooding (road impairments, small storms lend big effect)
- Mining Activities (quarries)
- Historic Bridges
- Isolated approach to solving local problems (Conservancy District Boundaries)

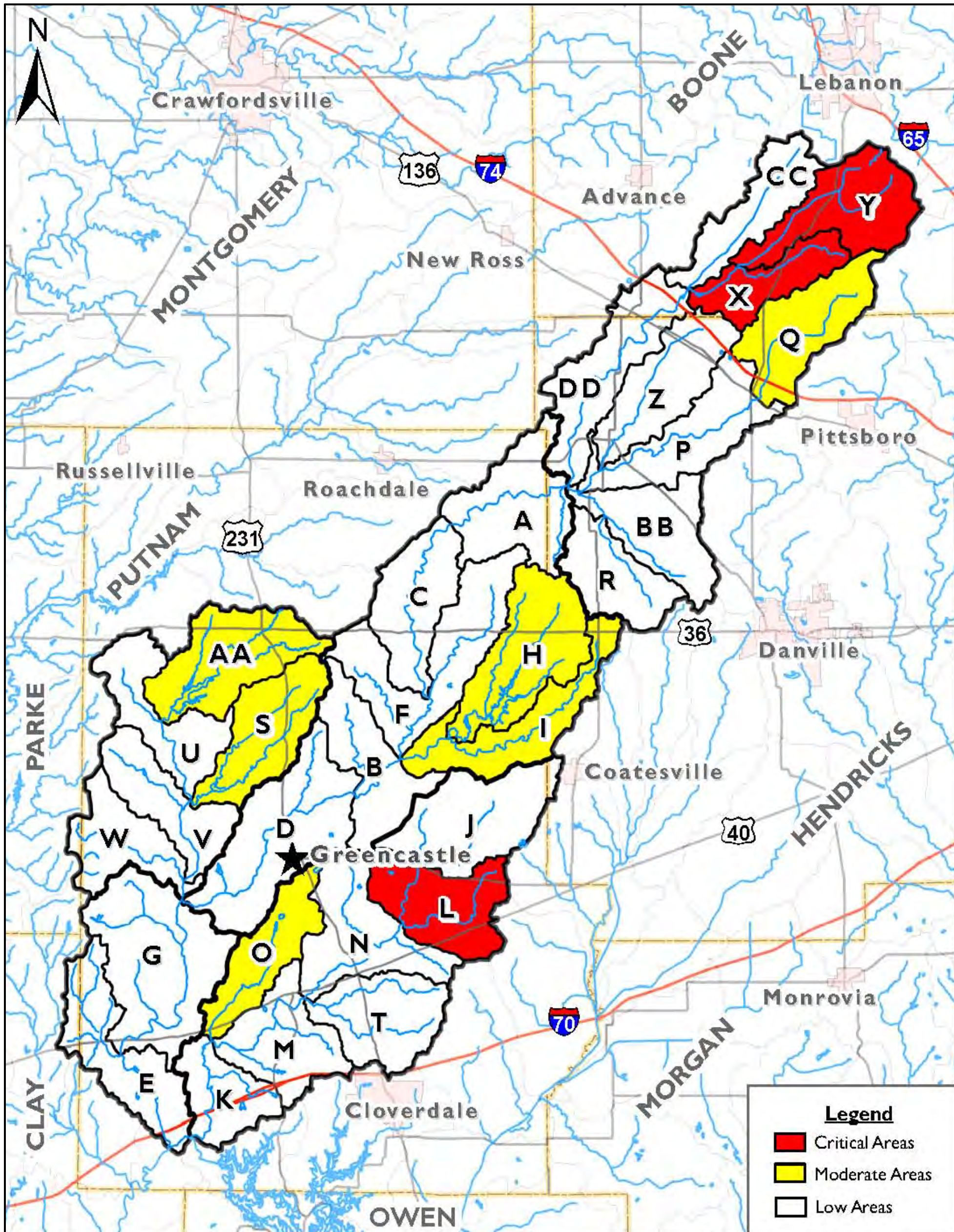



Figure O - Critical Areas Determined by Dr. Gammon

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

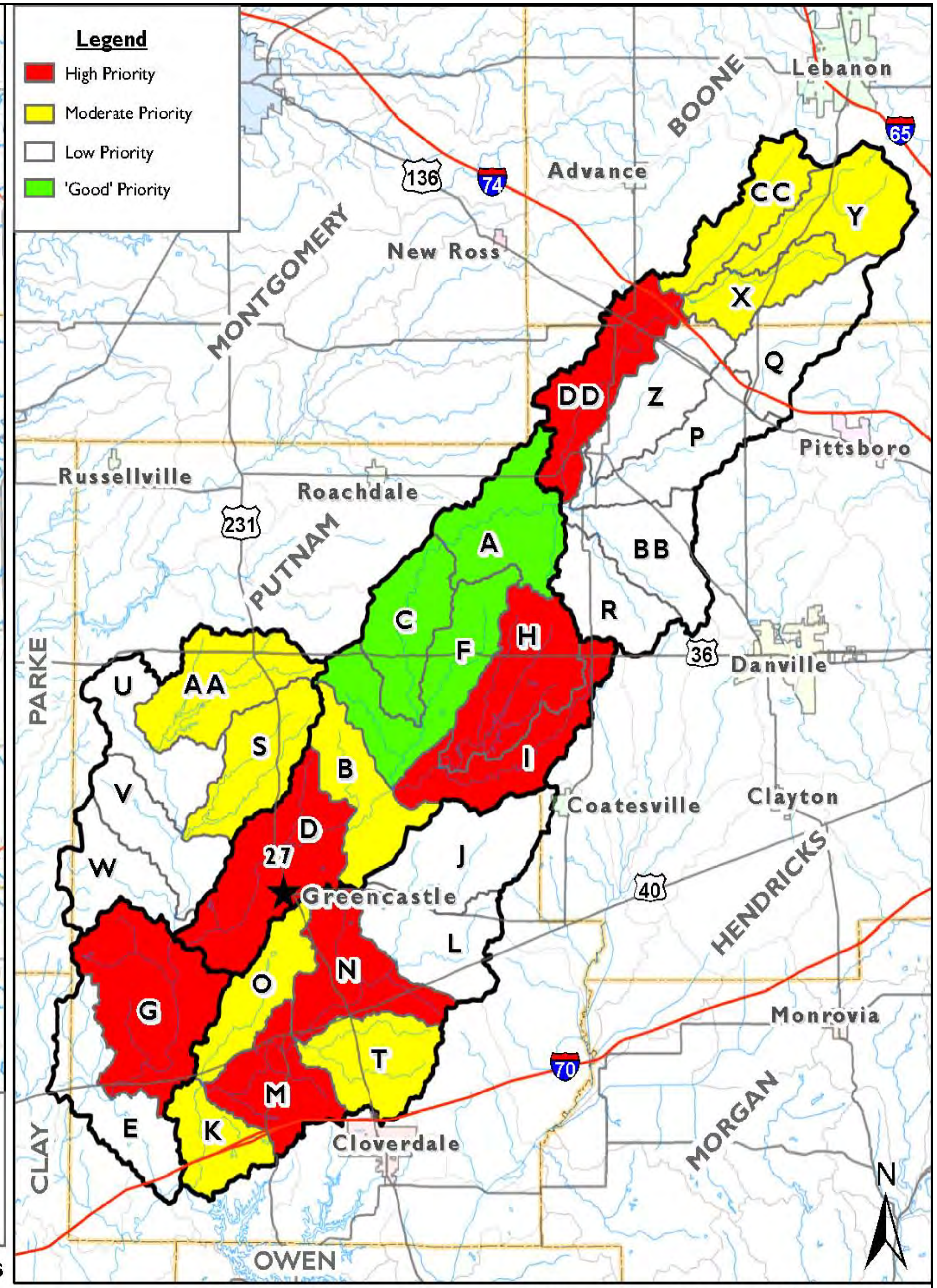



Figure AA - Priority Subwatersheds

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

**Figure BB — Priority Subwatershed Comparison**

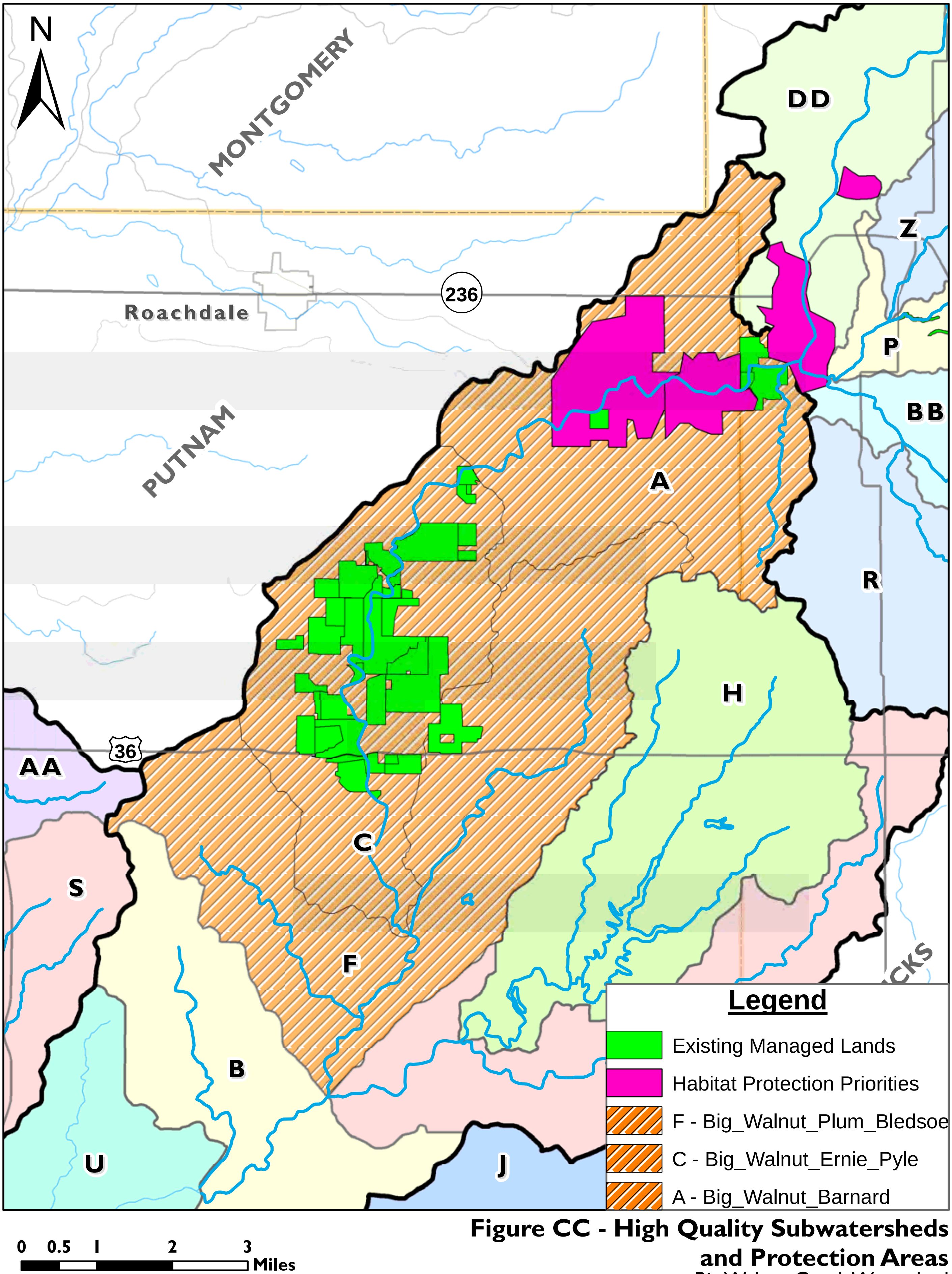



**Figure CC - High Quality Subwatersheds and Protection Areas**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

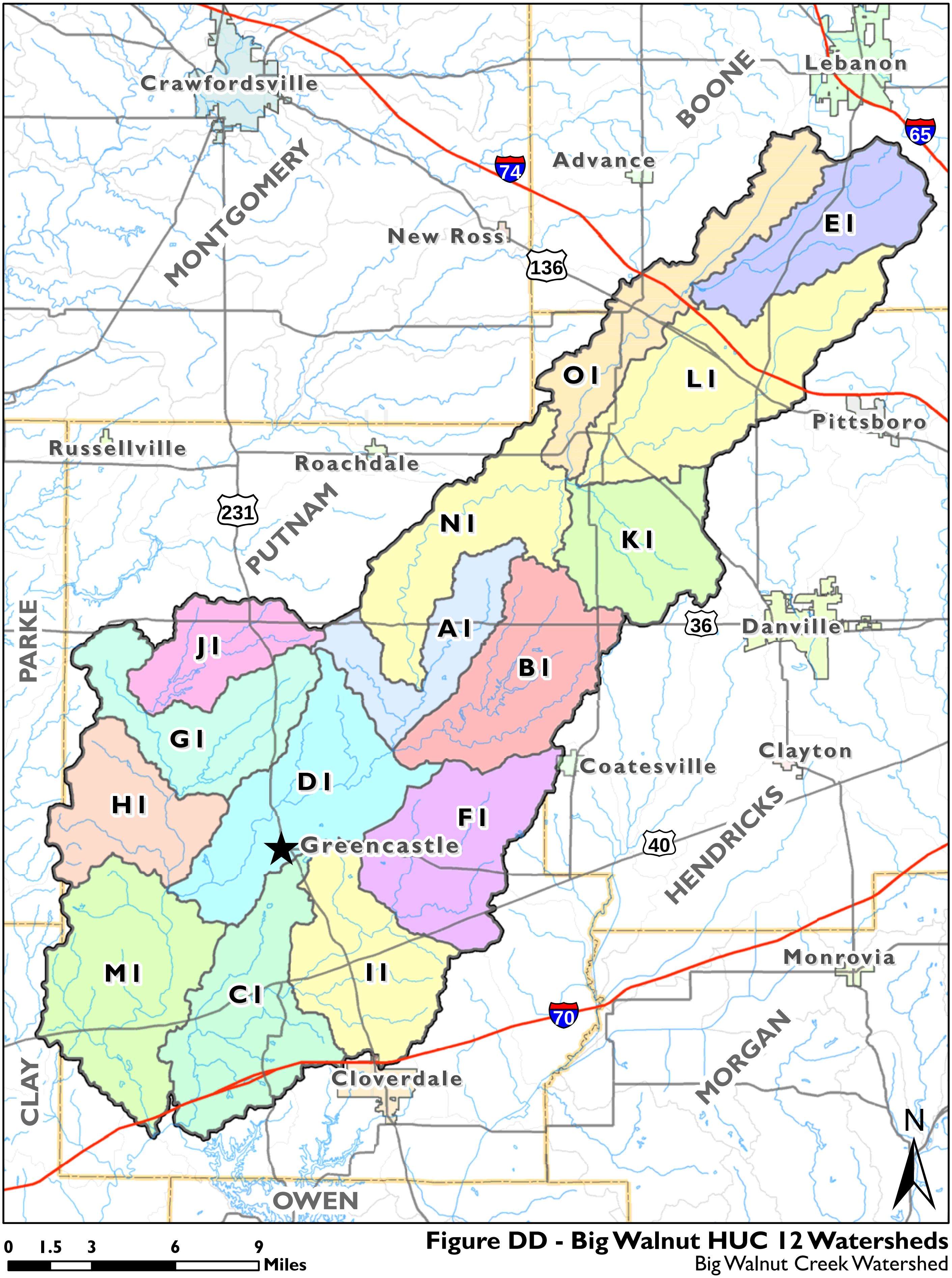



**Figure DD - Big Walnut HUC 12 Watersheds**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

Upon reviewing the above list and water quality data collected as part of this project, the Steering Committee identified the following additional or related concerns:

- E. coli bacteria levels higher than the State standards in many locations
- Elevated nutrient levels especially in the headwaters and around Greencastle
- High loads of organic matter (elevated BOD at some locations)
- Habitat is degraded in certain areas/habitat improvement may improve water quality
- Ground water withdrawal and recharge
- Lack of public education on environmental topics (timing of impacts, who is affected and how, drinkability and recreation potential or limitations)
- Land use practices (impacts on velocity of water and erosion)
- Erosion from in-stream meandering, bridge building, and location of erodible soils
- Increased run-off from urban areas
- Location, connection, and protection of conservation areas/natural areas
- Failing septic systems (homeowner regulatory fears, cost or repairs, no cost share programs, education on maintenance practices)
- Corridor and floodplain protection
- Strategic placement/planning for development (i.e. "controlled sprawl")
- Low flow water quality (stagnant water, algae blooms)

Following a review of the issues and focus of the original grant request for this project, the following issues/concerns identified by the public were determined to be outside of this project's approach and therefore will not be addressed in this Watershed Management Plan.

- Patterns of Flooding (road impairments, small storms lend big effect)
- Flood Prevention – role of bridges, control structures, etc. cost/benefit of structures
- Historic Bridges
- Mining Regulation
- Economic Development (tax base for Bainbridge, Cloverdale, Greencastle)

## 9.2 Problems and Causes

After an evaluation of all the above information, watershed problems can be summarized with the following problem statements:

1. Nutrient loads, associated BOD loads and subsequent oxygen sags threaten the health of Big Walnut Creek and its tributaries.
2. E. coli loads create unsafe recreational conditions in certain locations of Big Walnut Creek and its tributaries.
3. Too many livestock have access to watershed streams leading to nutrient, erosion, and E. coli problems.
4. Many septic systems are located in poorly drained soils and are poorly maintained contributing to *E. coli* concerns.
5. Several segments of stream, particularly the headwaters, are poorly buffered leading to poor in-stream habitat and non-point source pollution impacts.
6. Poor buffers and lack of floodplain protection and corridor planning are leaving important natural areas vulnerable.
7. Several segments of stream shows signs on in-stream/bank erosion and Total Suspended Solids (TSS) measurements confirm sediment impacts in some locations.

8. Low flow conditions lead to poor water quality and general concern about water quality and use in the watershed.
9. Increasing urban runoff is carrying more pollutants into Big Walnut Creek; yet, there are limited educational materials and cost share programs for average citizens and urban stakeholders.

### 9.3 Sources of Pollution

Nonpoint pollution sources are varied, yet common throughout almost any watershed. Several earlier sections of this document including the above Section 9.2 and Subsections of Section 5.3 denote possible sources of the pollutants of concern in the Big Walnut Watershed. However as a matter of summary, source of various pollutants are included below:

Nutrients –

- Conventional cropping practices
- Waste water treatment discharges
- Industrial discharges
- Landfill leachate
- Agricultural fertilizer
- Residential fertilizer
- Construction site runoff
- Animal/human waste (including septic systems)

BOD –

- Conventional cropping practices
- Waste water treatment discharges
- Industrial discharges
- Landfill leachate
- Algae (induced by fertilizers)
- Animal/human waste (including septic systems)
- Grass/lawn clipping or natural plant matter

*E. coli* –

- Human waste (including septic systems)
- Animal waste (including livestock in stream and poor manure management)
- Urban runoff (pet waste)
- Wildlife

Sediment –

- Conventional cropping practices
- Industrial discharges
- Mining operations
- In-stream erosion
- High velocities or increased urban run-off
- Construction activities

- Cattle trampling banks

As noted in Section 4.4, the Big Walnut Creek watershed has several NPDES point source dischargers, many of which are regularly out of compliance. These industrial or municipal dischargers should also be approached as part of the overall watershed planning and implementation process. With these point sources regularly present in some of the priority subwatersheds it becomes harder to narrow down suspected nonpoint sources of pollutants.

# 10.0 GOALS

## 10.1 Broad Project Goals Based on Public Concern

The Steering Committee reviewed the concerns raised by the public, as well as early-stage water quality findings to arrive at broad concerns and project goals. Specific concerns outlined in Section 9.1 were lumped together and can be found listed under the broad goals outlined below.

Sediment Concern = Erosion Goal

- Land use and practices in headwaters (Boone and Hendricks Counties)
- Land use practices (impacts on velocity of water and erosion)
- Sedimentation (brown water)
- Saving Soil
- Erosion from in-stream meandering, bridge building, and location of erodible soils
- Mining Activities (quarries)

Pollutants = Water Quality Goal(s)

- E. coli bacteria levels higher than the State standards in many locations
- Elevated nutrient levels especially in the headwaters and around Greencastle
- High loads of organic matter (elevated BOD at some locations)
- Low flow water quality (stagnant water, algae blooms)

Resource Protection and Loss = Habitat and Recreation Goal

- Location, connection, and protection of conservation areas/natural areas
- Habitat is degraded in certain areas/habitat improvement may improve water quality
- Corridor and floodplain protection
- Trail Connections (along streams, public access)

Growth Impacts = Land Use / Future Development Goal

- Strategic placement/planning for development (i.e. “controlled sprawl”)
- Increased run-off from urban areas
- Ground water withdrawal and recharge
- Growth rate and sewers – need for commercial growth
- Failing septic systems (homeowner regulatory fears, cost or repairs, no cost share programs, education on maintenance practices

Lack of Knowledge = Education/Outreach Goal

- Lack of public education on environmental topics (timing of impacts, who is affected and how, drinkability and recreation potential or limitations)
- Isolated approach to solving local problems (Conservancy District Boundaries)

## 10.2 Specific Goals and Water Quality Targets

After review of the above-mentioned broad goals, the Steering Committee worked to refine the project goals and develop pollution reduction targets. The following five major goals address all of the issues raised and articulated in the Problem Statements in Section 9.2. Water quality data collected as part of this project was used to determine target load reductions.

**<u>Goal 1:</u> Reduce soil erosion and sediment inputs into streams that result in a 1% TSS reduction in 5 years.**

This goal and water quality target was determined by a brief literature review and conversations with a local expert (Mr. Greg Bright). Bright actually suggested a higher concentration value of 50 mg/l; however, the current water quality data for most sample sites already displayed concentrations lower than this value. Literature (Holbeck-Pelham and Rasmussen, 1997) helped identified a more applicable target concentration (25mg/l) that would be indicative of healthy to above average aquatic life in similar Mid-western streams. Upon comparison of this concentration to current data concentrations, the above load reduction target was established by substituting 25 mg/l TSS in for all sites that exceeded this value, then recalculating loads. The difference in the newly calculated load was then subtracted from the true/original load. The difference between loads was compared to arrive at an appropriate reduction target.

**<u>Goal 2:</u> Reduce Total Phosphorus and Nitrate inputs by 20% in 5 years and Nitrate inputs by 40% in 10 yrs.**

This goal was determined by a brief literature review and conversations with a local water quality expert (Mr. Greg Bright) that helped identified target concentrations (0.2 mg/l Total Phosphorus, 2.0 mg/l Nitrate) that would be indicative of healthy to above average aquatic life in similar Mid-western streams. Upon comparison of this concentration to current data concentrations, the above load reduction target was established as described above for TSS. It should be noted that the Steering Committee intentionally did not link the water quality target directly to future concentration values due to concerns about low flow impacts creating conditions that make achieving the goal a moving target that can be seasonally affected.

A 20% reduction in Total Phosphorus represents what would be needed to have all sample sites display target concentration. The Steering Committee felt this reduction would be possible in 5 years of BMP implementation. Nitrate reduction is the biggest challenge among the various parameters. If all sites displayed target concentrations, a 40% load reduction would result. The Steering Committee thought this percent reduction would require a longer time frame and a variety of

BMP and compliance solutions; thus, a stepped approach was outlined over a ten year period.

**Goals 3: Reduce *E. coli* inputs such that all sample sites meet the State water quality standard of 235 cfu/100ml during base flow conditions and no more than 15% of the sites exceed the standard during storm flow conditions in 5 years. The long-term goal (10 years) is for all storm flow events to meet State water quality standards.**

Since so few of the sites exceed State standards in base flow conditions, the Steering Committee felt a reduction of E. coli inputs resulting in all sites meeting State standards during base flow was achievable in five years. However, since the inputs are much larger during storm events, a stepped approach was outlined over a ten year period for storm event samples/conditions. Currently, about 30% of all sites exceed State standards in storm flow conditions. A 50% reduction is targeted in the first five years of BMP implementation, with the remaining 50% being achieved in ten years.

**Goal 4: Protect and enhance important and unique natural aspects of Big Walnut Creek and its watershed (endangered and high quality species/natural areas).**

This goal was developed in response to public concerns about protection of existing conservation areas/natural areas, habitat degradation, corridor and floodplain protection and trail connections (along streams, public access sites). Several land holding stakeholders (IDNR, CILTI, TNC) participate on the Steering Committee and are interested in protecting and restoring several areas in the watershed. Water quality monitoring data also helped identify the functional role of some of the unique aspects of Big Walnut natural areas in Subwatersheds A, C, and F.

**Goal 5: Develop public awareness on how individual activities and actions will/do impact the watershed.**

This goal was developed in response to public concerns about the lack of public education on environmental topics. Several of the problems and sources of pollution are a direct result of limited public awareness regarding the negative impacts individuals and the collective behavior of a community can have on water quality. Awareness and education is needed regarding septic systems, water use, fertilizers, and managing animal waste. Concerns related to pollutant loads and stormwater runoff could be address using education as the primary BMP.

## 11.0 STRATEGIES

The Steering Committee then developed strategies to help address the project goals. The strategies are designed to help mold public outreach throughout the project and develop a work plan for various stakeholders, particularly the local Soil and Water Conservation Districts to begin targeted BMP implementation into the future. Action items associated with each strategy were identified by the Steering Committee and a rough schedule was assigned. The schedule was defined by three timeframes: 2009-2010 (immediate), 2010-2012 (near future/next grant cycle), 2012-2019 (later, planning or earlier steps required). Table 19 reflects these strategies and action items. The following section, Section 12.0, works to identify more specifically where the strategies related to Best Management Practices (BMPs) could or should be targeted based on the characteristics and water quality concerns of each priority subwatershed.

## 12.0 BEST MANAGEMENT PRACTICE SELECTION BY SUBWATERSHED

Best Management Practices (BMPs) were selected by for each priority subwatershed using several criteria. Table 20 summarizes some of the criteria used for making decisions on BMP selections in each subwatershed. Topics listed in the table are related to current land use and existing load conditions. The table includes such information as predominate land use, NPDES dischargers, and prevalence of hydric soils and floodplain. Topics such as buffer restoration potential, wetland restoration potential, and floodplain restoration potential indicate that there are many areas where this could occur. In addition to this table, BMPs were also selected based on Steering Committee input and water quality issues within the subwatersheds that caused them to be selected as priority subwatershed.

Once the makeup of the watershed was understood, several BMP selections were made for each subwatershed. At this time BMPs are not being targeted to specific areas within critical subwatersheds due to the number and total acreage of the subwatersheds. The Steering Committee will continue to work with the local SWCDs and NRCS to identify landowners willing to participate in the implementation of BMPs. These selections are listed in Table 21.

### 12.1 Load Reduction Targets – BMP Options

Table 22 lists BMP installation recommendation options for load reductions in the priority subwatersheds. BMP load reductions were calculated using several different formulas based on the type of BMP and nutrient/sediment removal efficiencies for each type of BMP. Once general reductions for each BMP were calculated, the options were formulated based on load reduction quantity and time goals set in Section 10.2. Each option combination shown below reduces load parameters of nitrate, total phosphorus, total suspended solids, and *E. coli* below the targeted pollutant goal amount in the timeframe desired.

**Table 19: Strategies and Actions**

| Goal 1: Reduce soil erosion and sediment inputs into streams that result in a 1% reduction in 5 years. | | | | | |
|---|---|---|---|---|---|
| | | Schedule | | | |
| Strategy | Action Item | 2009-2010 | 2010-2012 | 2012-2019 | Responsible Party |
| Reduce sediment loads from agricultural run-off | Work with NRCS, SWCDs, and county drainage boards to identify partners in the agricultural community and communication mechanisms | ✓ | | | BWCWA Committees, SWCDs, NRCS, ISDA, FSA, Drainage Boards |
| | Work with NRCS and SWCDs to increase cover crop practices, no-till practices, and grassed waterway locations | | ✓ | | BWCWA Coordinator, Agricultural Liaison, and SWCDs/NRCS/ISDA |
| | Provide cost-share funding for education and demonstration projects | | ✓ | | BWCWA Committees and SWCDs |
| Reduce sediment loads from highly erodible areas | Work with NRCS and SWCD to identify areas with highly erodible soils and those areas impacted/eroded in flood events of 2008 | ✓ | | | BWCWA Coordinator, Agricultural Liaison, and SWCDs/NRCS/ISDA |
| | Work with NRCS and SWCD to target BMP installation to areas with highly erodible soils | ✓ | | | BWCWA Committees, Agricultural Liaison, and SWCDs/NRCS/ISDA |
| | Identify steep grade changes in the streams and look for areas to implement floodplain improvements or high flow storage | ✓ | | | BWCWA Coordinator and SWCDs/NRCS/ISDA, possible consultant assistance |

**Table 19: Strategies and Actions (cont)**

| Goal 1: Reduce soil erosion and sediment inputs into streams that result in a 1% reduction in 5 years. | | | | | |
|---|---|---|---|---|---|
| | | Schedule | | | |
| Strategy | Action Item | 2009-2010 | 2010-2012 | 2012-2019 | Responsible Party |
| Reduce sediment loads from floodplains and land adjacent to streams | Work with NRCS and SWCDs to identify areas with poor buffer widths adjacent to streams | ✓ | | | BWCWA Coordinator and SWCDs/NRCS/ISDA |
| | Target BMPs installation to floodplains and land adjacent to streams to help with bank stabilization and slow erosive flows | | ✓ | | BWCWA Committees, Coordinator, and SWCDs/NRCS/ISDA |
| Increase Rule 5 enforcement and improve SWPPP plan development and review | Get staff training in plan review and incentive or enforcement programs | | ✓ | | BWCWA Coordinator and SWCDs |
| | Identify partner that could help monitor and report any problem sites | | ✓ | | BWCWA Committees, Coordinator, and SWCDs |
| | Educate local contractors about Rule 5 and status of local water quality | ✓ | | | BWCWA Committees, Coordinator, and SWCDs |

**Table 19: Strategies and Actions (cont)**

| Goal 2: Reduce Total Phosphorus and Nitrate inputs by 20% in 5 years and Nitrate inputs by 40% in 10 years. | | | | | |
|---|---|---|---|---|---|
| | | Schedule | | | |
| Strategy | Action Item | 2009-2010 | 2010-2012 | 2012-2019 | Responsible Party |
| Reduce nutrient loads from agricultural run-off | Work with NRCS, SWCDs, and county drainage boards to identify partners in the agricultural community and communication mechanisms | ✓ | | | BWCWA Committees, SWCDs, NRCS, ISDA, FSA, Drainage Boards |
| | Work with NRCS and SWCDs to educate agricultural landowners on fertilizer reduction and application timing practices | ✓ | | | BWCWA Committees, Agricultural Liaison, and SWCDs/NRCS/ISDA |
| | Provide cost-share funding for education and demonstration projects | | ✓ | | BWCWA Committees, Coordinator, and SWCDs/NRCS/ISDA |
| | Work with NRCS and SWCDs to increase conservation tillage practices, buffers and nutrient management planning | ✓ | | | BWCWA Committees, Agricultural Liaison, and SWCDs/NRCS/ISDA |
| Reduce nutrient load by increasing riparian buffers/floodplain zones and wetland acreage | Work with NRCS, SWCDs, The Nature Conservancy, CILTI, and IDNR to identify suitable areas for restoration and partners | | ✓ | | BWCWA Committees, Coordinator, and conservation partners (CILTI, IDNR, TNC, SWCDs) |
| | Provide cost-share funding for buffers and wetland restoration and widely market the practices to appropriate landowners | | ✓ | | BWCWA Committees, Coordinator, and SWCDs/NRCS/ISDA |

**Table 19: Strategies and Actions (cont)**

| Goal 2: Reduce Total Phosphorus and Nitrate inputs by 20% in 5 years and Nitrate inputs by 40% in 10 years. | | | | | |
|---|---|---|---|---|---|
| | | Schedule | | | |
| Strategy | Action Item | 2009-2010 | 2010-2012 | 2012-2019 | Responsible Party |
| Reduce nutrient load from suburban and urban runoff | Develop and deliver education and outreach programs regarding sustainable fertilizer use | | ✓ | | BWCWA Committees, Coordinator, and SWCDs |
| | Identify local partners including realtors, home improvement stores, and chemical applicators that can share messages and provide phosphorus free fertilizers | ✓ | | | BWCWA Committees, Coordinator, and SWCDs |
| | Provide cost-share funding for education and residential demonstration projects | | ✓ | | BWCWA Committees, Coordinator, and SWCDs |

**Table 19: Strategies and Actions (cont)**

| Goal 3: Reduce *E. coli* inputs such that all sample sites meet the State water quality standard of 235 cfu/100mL during base flow conditions and no more than 15% of the sites exceed the standard during storm flow conditions in 5 years. The long-term goal (10 years) is for all storm flow events to meet State water quality standards. | | | | | |
|---|---|---|---|---|---|
| | | Schedule | | | |
| Strategy | Action Item | 2009-2010 | 2010-2012 | 2012-2019 | Responsible Party |
| Reduce *E. coli* levels from livestock with access to streams | Work with NRCS, SWCDs, and county drainage boards to identify partners in the agricultural community and communication mechanisms | ✓ | | | BWCWA Committees, SWCDs, NRCS, ISDA, FSA, Drainage Boards |
| | Install livestock exclusion fencing and alternative watering sources | | ✓ | | BWCWA Committees, Agricultural Liaison, and SWCDs/NRCS/ISDA |
| | Continue monitoring in critical areas to further pinpoint sources and locations | | | ✓ | BWCWA Coordinator, SWCDs, and DePauw |
| Reduce *E. coli* levels from agricultural runoff | Work with agricultural community to promote timing of manure application to fields and alternative manure management strategies | | ✓ | | BWCWA Committees, Agricultural Liaison, and SWCDs/NRCS/ISDA |
| | Install buffers and wetlands via a cost share program and market their benefits | | ✓ | | BWCWA Committees, Agricultural Liaison, and SWCDs/NRCS/ISDA |
| | Continue monitoring in critical areas to further pinpoint sources and locations | | | ✓ | BWCWA Coordinator, SWCDs, and DePauw |

**Table 19: Strategies and Actions (cont)**

| **Goal 3: Reduce *E. coli* inputs such that all sample sites meet the State water quality standard of 235 cfu/100mL during base flow conditions and no more than 15% of the sites exceed the standard during storm flow conditions in 5 years. The long-term goal (10 years) is for all storm flow events to meet State water quality standards.** | | | | | |
|---|---|---|---|---|---|
| | | Schedule | | | |
| Strategy | Action Item | 2009-2010 | 2010-2012 | 2012-2019 | Responsible Party |
| Reduce *E. coli* levels from failing or absent septic systems | Work with health departments to identify areas with failing or no septic systems | ✓ | | ✓ | BWCWA Coordinator, SWCDs and County Health Departments |
| | Host septic system care and maintenance workshops | | ✓ | | BWCWA Committees, SWCDs, and County Health Departments |
| | Work with health departments to create an ordinance requiring all properties sold with septic systems to have an inspection done at time of sale | | ✓ | | BWCWA Coordinator, SWCDs, County Health Departments, and realtors |
| | Continue monitoring in critical areas to further pinpoint sources and locations | | ✓ | | BWCWA Coordinator, SWCDs, and DePauw |

**Table 19: Strategies and Actions (cont)**

| Goal 4: Protect and enhance important and unique natural aspects of Big Walnut Creek and its watershed (endangered and high quality species/natural areas). | | | | | |
|---|---|---|---|---|---|
| | | Schedule | | | |
| Strategy | Action Item | 2009-2010 | 2010-2012 | 2012-2019 | Responsible Party |
| Raise public awareness of the importance of the protection/conservation of natural areas and impacts on water quality | Host fieldtrips - watershed tours, river trips through nature preserves in watershed | | ✓ | | BWCWA Committees, Coordinator, and conservation partners (CILTI, IDNR, TNC, SWCDs) |
| | Build on McCloud Nature Park as an example property | | ✓ | | BWCWA Committees and Hendrick County parks and SWCD |
| | Purchase or assist with conservation easements on important properties | | | ✓ | BWCWA Coordinator and conservation partners (CILTI, IDNR, TNC, SWCDs) |
| | Fund plantings outside of 100-year floodplain to get whole field plantings | | ✓ | | BWCWA Committees, NRCS and SWCDs |
| | Restore lands adjacent to unique resources through cost-share funding or local mitigation projects/coordination | | ✓ | | BWCWA Committees and development community |
| | Collect data and create case studies and/or marketing material about the impacts of the 2008 floods and role of floodplains | ✓ | | | BWCWA Committees, Coordinator, and Putnam Co SWCD |

**Table 19: Strategies and Actions (cont)**

| Goal 4: Protect and enhance important and unique natural aspects of Big Walnut Creek and its watershed (endangered and high quality species/natural areas). | | | | | |
|---|---|---|---|---|---|
| | | Schedule | | | |
| Strategy | Action Item | 2009-2010 | 2010-2012 | 2012-2019 | Responsible Party |
| Raise public awareness of the importance of the protection/conservation of natural areas and impacts on water quality | Work with IDNR to hold training sessions for local interpreters/naturalists | | ✓ | | BWCWA Coordinator and IDNR |
| | Work with TNC, IDNR, and CILTI to promote field work days (e.g. invasive species removal, clean-ups, habitat improvements, etc.) | | ✓ | | BWCWA Committees, Coordinator, and conservation partners (CILTI, IDNR, TNC, SWCDs) |
| Influence landuse planning at the local and county levels | Participate and/or attend Plan Commission meetings | ✓ | | | BWCWA Coordinator and SWCD staff |
| | Review local planning documents and make recommendations to staff regarding protection of important natural areas | ✓ | | | BWCWA Committees and Coordinator |
| Document 2008 flood impacts and identify important floodplains and riparian areas | Use 2008 damage assessments to identify areas for restoration | ✓ | | | BWCWA Coordinator, NRCS, and Putnam Co SWCD |
| Identify important corridors for habitat | Work with CILTI, IDNR, and TNC to identify corridor management strategies and locations | ✓ | | | BWCWA Committees, Coordinator, and conservation partners (CILTI, IDNR, TNC) |
| | Work with DePauw University to get students involved in planning and assessment of area habitats | ✓ | | | BWCWA Coordinator and DePauw University |

**Table 19: Strategies and Actions (cont)**

| Goal 5: Develop public awareness on how individual activities and actions will/do impact the watershed. | | | | | |
|---|---|---|---|---|---|
| | | Schedule | | | |
| Strategy | Action Item | 2009-2010 | 2010-2012 | 2012-2019 | Responsible Party |
| Provide "hands-on" opportunities for people to learn about individual BMPs | Host fieldtrips - watershed tours, river trips showing land use and impacts, both positive and negative | | ✓ | | BWCWA Committees, Coordinator, and conservation partners (CILTI, IDNR, TNC, SWCDs) |
| | Promote and provide cost-share for equipment purchase and/or rental program for self-installation of BMPs | | ✓ | | BWCWA Committees, Coordinator, Agricultural Liaison and SWCDs |
| | Host workshops that teach about what can be done on individual residential properties (backyard conservation) | | ✓ | | BWCWA Committees, Coordinator, and SWCDs |
| | Give presentation and conduct interactive activities at neighborhood meetings, local service club meetings, etc. | ✓ | | | BWCWA Coordinator and SWCDs |
| | Create demonstration sites on public properties with help from volunteers | | ✓ | | BWCWA Committees and conservation partners (CILTI, IDNR, TNC, SWCDs) |

**Table 19: Strategies and Actions (cont)**

| Goal 5: Develop public awareness on how individual activities and actions will/do impact the watershed. | | | | | |
|---|---|---|---|---|---|
| | | Schedule | | | |
| Strategy | Action Item | 2009-2010 | 2010-2012 | 2012-2019 | Responsible Party |
| Develop an targeted educational program and materials | Conduct a statistically valid, widespread watershed survey | | ✓ | | BWCWA Committee, , Coordinator, and Purdue Univerity |
| | Create a logo and key messages | ✓ | | | BWCWA Committee |
| | Identify partnerships with other stakeholders to find new venues to educate the public about water quality issues (partner with MS4s) | ✓ | | | BWCWA Committees, , Coordinator, conservation partners (CILTI, IDNR, TNC, SWCDs), and MS4s |
| | Utilize the Visitor Centers and tourism community | ✓ | | | BWCWA Coordinator, counties officials, and cities/towns |
| | Create tangible materials based on survey findings (e.g. website tools, graphics, brochures, handouts, displays, etc.) | | ✓ | | BWCWA Committees and Coordinator |
| | Create and build upon school programs | | ✓ | | BWCWA Coordinator and SWCDs |
| Create a comprehensive septic system education program | Work with health departments to identify areas with failing or no septic systems | ✓ | | | Coordinator, SWCDs and County Health Departments |
| | Host septic system care and maintenance workshops | | ✓ | | BWCWA Committees and SWCDs |
| | Work with health departments to create an ordinance requiring all properties sold with septic systems to have an inspection done at time of sale | | ✓ | | BWCWA Committees, Coordinator, County Health Departments, Realtors |
| | Develop septic system exhibit for county fair (demonstrate impacts on water quality) | | ✓ | | BWCWA Committees and SWCDs |

**Table 20: BMP Selection Criteria**

| | Priority Subs | Current Land Use | NPDES Discharger | Wetland Restoration Potential (hydric soils) | Buffer Restoration Potential | CFO/Livestock in Streams | Floodplain Restoration Potential |
|---|---|---|---|---|---|---|---|
| B | Big Walnut Creek - Dry Branch | Agriculture | Int'l Business Machines | Low | Low | Low | Medium |
| D | Big Walnut Creek - Greencastle | Suburban/ Forest | Greencastle Dept of Water; Greencastle STP; United (Speedway Gas) | Low | Low | Medium | High |
| G | Big Walnut Creek - Snake Creek/Maiden Run | Forest | Reelsville Elem School; Reelsville Water Treatment Plant | Low | Low | High | High |
| H | Clear Creek Headwaters (Putnam) | Agriculture | Clear Creek Conservancy District - Sewerage System | Low | Medium | Low | High |
| I | Clear Creek - Miller Creek | Agriculture | | Low | Medium | High | Medium |
| K | Deer Creek - Leatherwood Creek | Forest | | Low | Low | Low | Low |
| M | Deer Creek - Mosquito Creek | Forest | Putnamville Correctional Facility | Low | Low | Low | High |
| N | Deer Creek - Owl Branch | Suburban/ Forest | | Low | Low | High | Medium |

**Table 20: BMP Selection Criteria (cont)**

| Priority Subs | | Current Land Use | NPDES Discharger | Wetland Restoration Potential (hydric soils) | Buffer Restoration Potential | CFO/Livestock in Streams | Floodplain Restoration Potential |
|---|---|---|---|---|---|---|---|
| O | Deweese Creek | Suburban/ Forest | Lone Star Industries Landfill; Buzzi Unicem | Low | Low | Low | Low |
| S | Jones Creek | Agriculture | | Low | Low | Medium | Low |
| T | Limestone Creek | Agriculture/Forest | Martin Marietta; South Putnam HS; Altra Indiana | Low | Low | Medium | Low |
| X | Main Edlin Ditch - Grassy Branch | Agriculture | | High | Medium | Low | High |
| Y | Main Edlin Ditch - Smith Ditch | Agriculture | | High | High | Low | High |
| AA | Owl Creek | Agriculture | Van Bibber Conservancy District - Sewerage System; Van Bibber Water Treatment Plant | Low | Low | Low | Low |
| CC | West Fork Big Walnut Creek Headwaters | Agriculture | | High | Medium | Low | High |
| DD | West Fork Big Walnut Creek - Lower | Agriculture | Jamestown WWTP | Medium | Low | High | High |

**Table 21: BMP Selections**

| Priority Subs | | Preferred BMPs to Address Water Quality Issues in Priority Subwatersheds | Other Recommendations |
|---|---|---|---|
| B | Big Walnut Creek - Dry Branch | livestock fencing; alternative watering; streambank stabilization; cover crops; nutrient management for cropland; CNMPs; fertilizer storage | |
| D | Big Walnut Creek - Greencastle | urban practices (rain gardens); buffers/floodplain restoration; livestock fencing; alternative watering; nutrient management for cropland; CNMPs; fertilizer storage; streambank stabilization | septic system education; forest stand improvement; grazing practices |
| G | Big Walnut Creek - Snake Creek/Maiden Run | livestock exclusion fencing; floodplain restoration; nutrient management for cropland; CNMPs; fertilizer storage; manure management - pit closure (CFO) | septic system education; forest stand improvement; grazing practices |
| H | Clear Creek Headwaters (Putnam) | urban residential practices (rain gardens); livestock fencing; alternative watering sources; buffers; manure management; cover crops | septic system education |
| I | Clear Creek - Miller Creek | livestock fencing; alternative watering sources; buffers; manure management; nutrient management for cropland; CNMPs; fertilizer storage; cover crops | septic system education |
| K | Deer Creek - Leatherwood Creek | instream grade stabilization | additional monitoring to isolate location of pollution impacts (landuse does not reconcile with large nutrient and sediment loads) |
| M | Deer Creek - Mosquito Creek | buffers/floodplain restoration | NPDES Dischargers compliance |

**Table 21: BMP Selections (cont)**

| Priority Subs | | Preferred BMPs to Address Water Quality Issues in Priority Subwatersheds | Other Recommendations |
|---|---|---|---|
| N | Deer Creek - Owl Branch | urban practices (rain gardens); bioswales/parking lot islands; livestock fencing; alternative watering sources; nutrient management for cropland; CNMPs; fertilizer storage; buffers/floodplain restoration | forest stand improvement; grazing practices |
| O | Deweese Creek | urban practices (rain gardens); manure management; nutrient management for cropland; CNMPs; fertilizer storage | NPDES Dischargers compliance; septic system education |
| S | Jones Creek | livestock fencing; alternative watering sources; cover crop | additional monitoring to isolate location of pollution impacts |
| T | Limestone Creek | livestock fencing; alternative watering sources; manure management; cover crop | NPDES Dischargers compliance |
| X | Main Edlin Ditch - Grassy Branch | wetland restoration; buffer/floodplain restoration; cover crop; mulch and no-till; manure management | |
| Y | Main Edlin Ditch - Smith Ditch | wetland restoration; buffer/floodplain restoration; cover crop; mulch and no-till; manure management | |
| AA | Owl Creek | land use planning/zoning | septic system education; NPDES Discharger compliance; additional monitoring south of reservoir |
| CC | West Fork Big Walnut Creek Headwaters | wetland restoration; buffer/floodplain restoration; cover crop; mulch and no-till | junkyard clean-up/compliance |
| DD | West Fork Big Walnut Creek - Lower | wetland restoration; buffer/floodplain restoration; cover crop; livestock fencing; alternative watering; nutrient management for cropland; CNMPs; fertilizer storage; urban practices | NPDES Dischargers compliance |

**Table 22: BMP Installation Recommendations for Load Reduction**

| BMP | Option A | Option B | Option C | Option D |
|---|---|---|---|---|
| Livestock Exclusion Fencing | 3000 linear feet | ---------- | 10000 linear feet | 15000 linear feet |
| Streambank Stabilization | 1000 linear feet | ---------- | 10000 linear feet | 5000 linear feet |
| No-Till Conversion | 5500 contributing acres | 7800 contributing acres | 2500 contributing acres | 4000 contributing acres |
| Buffer/Filter Strips | 2500 contributing acres | ---------- | 5000 contributing acres | 1500 contributing acres |
| Grassed Waterways | 12500 linear feet | ---------- | 15000 linear feet | 17500 linear feet |
| Bioretention | 5000 contributing acres | ---------- | 15000 contributing acres | 10000 contributing acres |
| Wetland Restoration | 2000 contributing acres | ---------- | 11000 contributing acres | 3000 contributing acres |

## 12.2 Cost Estimates

The Steering Committee has identified a number of different types of BMPs that they would like to see implemented to meet goals. Several of these practices are listed above in Table 22. General costs have been estimated for the installation of these practices. Table 23 reflects the costs for each of the options shown above. The costs for BMP options listed in Table 23 are calculated using the highest estimated cost available. Also, reduction options for several of the BMPs in Table 23 are (no-till conversion, buffer/filter strips, wetland restoration) calculated based on contributing of acres as seen in Table 21: BMP Installation Recommendations for Load Reductions. BMPs for these options are typically installed on per acre, per foot, or linear foot basis, not the number of contributing acres. Therefore if costs were calculated for these options, they would not be representative of actual costs for installation. If one of these BMP options is selected for installation and a location is determined the number of acres contributing to the BMP can be determined and the chosen BMP sized as necessary.

In addition to the costs for Table 23, there are numerous other practices that can be implemented to educate the public on water quality and related issues. These practices include such things as workshops, demonstration sites, and many others. Table 24 lists these BMPs in addition to a variety of other practices and associated costs that might be implemented in the watershed to reach goals.

## 12.3 Technical Assistance

A number of the BMPs selected for implementation will need assistance from technical specialists. The type and amount of technical assistance will vary from project to project. Below is a list of just a few of the technical resources available.

- Soil and Water Conservation Districts
- Natural Resource Conservation Service
- County Health Departments
- Resource Conservation and Development Council
- Indiana Department of Natural Resources

- Indiana Department of Environmental Management
- United States Geological Survey
- Central Indiana Land Trust, Inc.
- The Nature Conservancy
- County Surveyor's Offices
- County Drainage Boards

### 12.4 Financial Assistance

Financial assistance will be needed to implement a number of the BMPs. Assistance can come in the form of actual monetary notes or in the form of in-kind or technical services. Several funding options are available for BMP implementation, most of which are in the form of grants. Agencies that provide grants for BMP implementation include, but are not limited to:

- IDEM – Section 319 watershed management program for watershed implementation projects, staff and education programs/projects
- IDNR – Division of Fish and Wildlife Lake and River Enhancement (LARE) Program for watershed implementation projects and future monitoring, Division of Nature Preserves Heritage Trust Program for easements and restoration projects
- EPA – Several topical grant programs (stormwater projects, research projects, environmental justice projects, Community Action for a Renewed Environment (CARE) program, etc.)
- USGS – Topical research grants for nutrient transport or other nonpoint source water quality studies
- USACE – Some limited restoration funding
- Hoosier Riverwatch (IDNR) – Grants for advanced monitoring equipment
- Clean Water Indiana – Small grants to SWCDs for water quality, conservation and education projects
- United Way – Planning and restoration funds for flood stricken areas
- National Fish and Wildlife Foundation – Five-Star Restoration Matching Grants Program for watershed restoration projects, water quality and habitat projects
- Local developers – Mitigation projects/dollars associated with planned wetland or stream impacts

In addition to these sources, Appendix B of the Indiana Watershed Planning Guide put together by the IDEM Office of Water Quality Watershed Management Section, lists other sources and websites of potential funding sources.

## 13.0 SUCCESS MEASURES

The overall success of a watershed management plan depends up on the implementation of action items as set up by goals. Below are measureable success indicators or milestones which will help the BWCWA track its progress and aid in updating and revising the Plan as accomplishments/goals are met. Some of the goals are long term and regular monitoring will be necessary to make certain that stakeholder actions and prescribed strategies are helping realize the actual water quality targets.

**Table 23: BMP Installation Recommendation Costs**

| BMP | Costs* | Option A Costs | Option B Costs | Option C Costs | Option D Costs |
|---|---|---|---|---|---|
| Livestock Exclusion Fencing | $1.60/linear foot | $4,800.00 | $0.00 | $16,000.00 | $24,000.00 |
| Streambank Stabilization | $22-$32/linear foot | $32,000.00 | $0.00 | $320,000.00 | $160,000.00 |
| No-Till Conversion** | $10/acre | ** | ** | ** | ** |
| Buffer/Filter Strips** | dependent on type | dependent on type | dependent on type | dependent on type | dependent on type |
| filter strips or | $190/acre | ** | ** | ** | ** |
| forested buffer or | $500/acre | ** | ** | ** | ** |
| herbaceous buffer | $225/acre | ** | ** | ** | ** |
| Grassed Waterways | $2-$3.50/linear foot | $43,750.00 | $0.00 | $52,500.00 | $61,250.00 |
| Bioretention** | $5-$40/square foot | ** | ** | ** | ** |
| Wetland Restoration** | $1000-$2000/acre | ** | ** | ** | ** |

NOTES: *Costs are calculated using highest value listed.

**Options for these BMPs were calculated based on contributing number of acres as seen in Table 21: BMP Installation Recommendations for Load Reductions. BMPs for these options are typically installed on a per acre, per foot, or linear foot basis, not the number of contributing acres. Therefore if costs were calculated for these options, they would not be representative of actual costs for installation. If one of these BMP options is selected for installation and a location is determined the number of acres contributing to the BMP can be determined and the chosen BMP sized as necessary.

**Table 24: Other BMP Costs**

| BMP | Cost | Notes |
|---|---|---|
| Training Sessions/Workshops | $500 each | Variable depending on size and scope. |
| Newsletter/Mailing | $500 each | Variable depending on size and scope. |
| Newspaper Article | Free | Does not include staff/volunteer preparation time. |
| Educational Signage | Variable | Variable |
| Volunteer Water Quality Monitoring Program | $15,000/year | Includes part-time staff person and cost of test kits. |
| Nutrient Management | $9.00/acre | Costs related to technical assistance. |
| Chemical Management | $5.00/acre | Costs related to technical assistance. |
| Critical Area Planting | $1300/acre | Includes grading, planting, herbicides, mulch, and labor. |
| Water and Sediment Control Basin | $1700 each | |
| Grade Stabilization Structure | $1000 each | |
| Stripcropping | $12.00/acre | |
| Detention Ponds | $35,000-$110,000/acre | Cost includes engineering, excavation, fill, compaction, inlet and outlet installation, landscaping, and legal fees. |
| Field Windbreaks, Hedgerows | $1.50/linear foot | |
| Cover Crops | $14.00/acre | |
| Pasture/Hay Planting | $120-$150/acre | Cost dependent on type of grasses used. |
| Rain Garden/Bioretention Cell | $5.00-$40.00/square foot | Cost dependent on site requirements. Industrial and commercial sites may require professional engineering and control structures |

**Table 24: Other BMP Costs (cont)**

| BMP | Cost | Notes |
|---|---|---|
| Rain Barrel | $75-$200/each | Dependent on size and features. |
| Green Roof | $12.00-$24.00/square foot | Includes root repellant/waterproof membranes, and irrigation. Cost dependent on site requirements. |
| Streambank Stabilization | $22.00-$32.00/square foot | Dependent on site and method used. |
| Tree Planting | $0.50-$300/per tree | Dependent on size and species of tree, and if mulching and staking are involved. |
| Check Dams | $15.00/linear foot | |
| Parking Lot Islands/Bioswales | $0.04-$2.50/square foot | Cost dependent on site conditions and are based on seeding. |
| Downspout Disconnections | $15.00-$25.00/downspout | |
| Infiltration Trench | $4.00/linear foot | Assumes a 2 foot wide trench. Costs are variable depending on site requirements |
| Permeable Surfaces | $1.00-$5.00/square foot | Dependent on material type |
| Retrofit Detention Basin | $0.05-$3.00/square foot | Cost dependent on site conditions and are based on seeding. |

## 13.1 Goal 1: Reduce soil erosion and sediment inputs into streams that result in a 1% reduction in 5 years.

**Indicators:**

- ✓ Number of buffer strips/riparian buffers
- ✓ Increase in no-till acres
- ✓ Number of workshops (contractors, fairs)
- ✓ Number of urban BMPs (rain barrels, rain gardens) installed
- ✓ Number of acres of BMPs installed on highly erodible soils
- ✓ Number of practices implemented to reduce velocity in steeply graded areas
- ✓ Number of forestry BMPs installed
- ✓ Number of log jams removed/banks stabilized
- ✓ Number of demonstration sites
- ✓ Increased training and certification of Rule 5 staff and contractors
- ✓ Development of detailed buffer maps
- ✓ Reduced TSS concentrations and loads in water quality samples
- ✓ Improved mIBI scores
- ✓ Track weather and link to water quality samples (use water treatment plants)

## 13.2 Goal 2: Reduce Total Phosphorus and Nitrate inputs by 20% in 5 years and Nitrate inputs by 40% in 10 years.

**Indicators:**

- ✓ Number of sites identified for implementation
- ✓ Number of sites with BMPs implemented
- ✓ Number of linear feet of livestock fencing installed
- ✓ Number of acres/linear feet of riparian buffers
- ✓ Number of two-stage ditches installed
- ✓ Increase in no-till acres
- ✓ Number of nutrient management plans developed
- ✓ Number of field days and attendees
- ✓ Number of workshops/meetings and attendees
- ✓ Number of follow-up emails, appointments, etc. from field days/workshops
- ✓ Number of demonstration sites
- ✓ Number of stores carrying phosphorus free fertilizer
- ✓ Number of companies/applicators carrying phosphorus free fertilizer
- ✓ Number of lawn application of fertilizer or requests for phosphorus-free
- ✓ Reduced nutrient concentrations and loads in water quality samples
- ✓ Improved mIBI scores

## 13.3 Goal 3: Reduce *E. coli* inputs such that all sample sites meet the State water quality standard of 235 cfu/100mL during base flow conditions and no more than 15% of the sites exceed the standard during storm flow conditions in 5 years. The long-term goal (10 years) is for all storm flow events to meet State water quality standards.

**Indicators:**

- ✓ Number of partners identified and new communication venues utilized

- ✓ Number of landowners identified amenable to fencing, alternative water supplies, and manure management strategies
- ✓ Fewer number of visual observations of cattle in the stream
- ✓ Number of animals removed from stream by fencing
- ✓ Number of alternative water supply systems created
- ✓ Number of lagoons safely closed
- ✓ Number of lagoons, manure systems added/implemented
- ✓ Number of homeowner receiving education on septic systems/wastewater disposal
- ✓ Number of homeowner receiving education on inflow and infiltration polices
- ✓ Local ordinances developed to require all properties sold with septic systems have septic tests done at time of sale – guidelines for ordinance developed
- ✓ Meetings with NPDES dischargers
- ✓ Increased NPDES compliance
- ✓ Reduced *E. coli* concentrations and loads in storm water quality samples
- ✓ Currently impaired segments removed from 303d list
- ✓ Follow-up monitoring/improvements in water quality at Dr. Gammon's sites

## 13.4 Goal 4: Protect and enhance important and unique natural aspects of Big Walnut Creek and its watershed (endangered and high quality species/natural areas).

**Indicators:**

- ✓ Number of key areas identified for protection or restoration
- ✓ Increase acres of natural areas through TNC, IDNR, and Wabash Land Trusts
- ✓ Increase acres planted in forest in bottom lands/floodplains
- ✓ Reduction in exotic/invasive infestations (aquatic and terrestrial)
- ✓ Number of learning opportunities about diverse habitat within basin
- ✓ Number of riparian buffer installed
- ✓ Number of easements on important ecological or corridor-building properties
- ✓ Increase smallmouth bass percentage in fish community
- ✓ Decrease algae blooms/reduced chlorophyll a concentrations
- ✓ Increase redhorse population, more gravel streambeds, less sedimentation observed in scientific surveys
- ✓ Increase acreage of Canadian/Eastern Hemlock
- ✓ Numbers of meeting with planning authorities
- ✓ Recommendations made to planning authorities
- ✓ Land use plans changed or amended to protect riparian areas
- ✓ Improved mIBI scores and QHEI scores

## 13.5 Goal 5: Develop public awareness on how individual activities and actions will/do impact the watershed.

**Indicators:**

- ✓ Number of students/year educated on how individual activities and actions will/do impact the watershed
- ✓ Number of individuals who attend tours or workshops
- ✓ Number of individuals in attendance at presentations or number of groups reached
- ✓ Number of articles published on watersheds/quality in local media

- ✓ Tangible educational materials produce and reproduced
- ✓ Increased coordination with DePauw University (coordinated research, engage sustainability program)
- ✓ Number of meetings with students at DePauw ('water group' newly formed)
- ✓ Increased coordination with TNC outreach programs and research
- ✓ Number of student/volunteer clean-up days for watershed maintenance
- ✓ Development of workshop/info package on septic system operations/maintenance
- ✓ Production of resource guide for where to find BMP information/soil information
- ✓ Number of people participating in committees
- ✓ Number of email inquiries
- ✓ Number of people receiving messages (pending deliver mechanisms identified in the survey)
- ✓ Development a display to take to fairs, festivals
- ✓ Number of contractors contacted or educated

# 14.0 MONITORING EFFECTIVENESS

## 14.1 Leadership Structure and Public Involvement

The Big Walnut Creek Watershed Alliance (BWCWA) is committed to generating and executing a successful watershed management plan that will protect, enhance, and conserve the Big Walnut Creek Watershed. In order to implement a successful management plan, continued cooperation, research, and financial support will be needed from key players in the watershed.

The steering committee of the Big Walnut Creek Watershed Alliance will continue to meet on a regular basis for the purpose of plan implementation. The steering committee will review project efforts according to the management plan's goals, objectives, and action items on an as needed basis.

The BWCWA has determined that the management plan will be a living document. As a living document it will occasionally need to be updated in order to address changing and future concerns of its group members. In order to understand changes within the watershed, the group will continue to host annual public meetings to gather public input and participation from watershed landowners.

## 14.2 Implementation Progress

Overall project progress will be tracked by measurable items such as workshops held, BMPs installed, and demonstration sites installed. Load reductions will also be calculated as each BMP is installed. These values and associated project details (e.g. BMP type, location, length of conservation commitment/easement, size, cost, etc.) will be tracked over time in a single spreadsheet. This spreadsheet will provide a single tracking mechanism for all projects installed and programs implemented in the watershed. Individual landowner information will be tracked by staff from various federal or state funding programs.

## 14.3 Water Quality Monitoring

Water quality monitoring will continue to be tracked with biannual sampling in order to determine annual load reductions. Pending funding opportunities, such monitoring may need to be conducted via Riverwatch sampling methods. The sites sampled as part of this Plan will be revisited as part of this future monitoring plan. Additional sites may be added to help further identify possible pollution sources and/or document pre/post implementation effects.

# 15.0 INSTITUTIONAL RESOURCES

As noted above, implement a successful management plan will require participation of several key players in the watershed. A large variety of institutional resources exist in the watershed to aid in water quality improvement and implementation efforts. These range from local government offices, state and federal agency personnel/programs, and non-profit conservation organizations. The following sub-sections will outline some of their various roles, resources, and contact information.

## 15.1 Local County Government Offices

### 15.1.1 Soil & Water Conservation Districts

Indiana's Soil and Water Conservation Districts (SWCDs) were established by the Indiana Conservation Act (IC 14-32). SWCDs are chartered, legal subdivisions of State Government whose territories are aligned with county boundaries. SWCDs develop and implement conservation programs based on a set of resource priorities, and channel resources from all levels of government into action at the local/county level. Indiana's 92 SWCDs are each governed by a board of supervisors, consisting of three elected supervisors, who own or rent more than 10 acres of land in the district, and two appointed supervisors who maintain their permanent residence in the district.

<u>BOONE COUNTY SOIL AND WATER CONSERVATION DISTRICT</u>

The Boone County SWCD focuses on the delivery of traditional conservation programs to county residents. These include all of the Farm Bill programs and any other associated local initiatives. The District's was also recently awarded a Clean Water Indiana grant aimed at increasing and improving nutrient management practices. The grant centers around a cost-share program that includes soil testing and nutrient management plan development.

While the Boone County SWCD offers intermittent educational events and field days, the District does not have routine, formal, educational program. The current Clean Water Indiana grant has a conservation marketing component which will result in promotional materials and "shop meetings" with farmers at on-site field locations across the county.

Given the County Surveyor's role in stormwater management and erosion control, the District does not participate in Rule 5 inspections or enforcements. Due to limited resources and the desire to focus on the implementation of conservation programs, the District is not conducting any volunteer water quality monitoring.

The SWCD Board meets the fourth Wednesday of the month at 7:30am in the Boone County Office Building, Connie Lamar Room

For questions regarding any of Boone County SWCD's programs contact:

Scheryl Vaughn
Boone County Soil & Water Conservation District
Office Administrator/Educator
416 W. Camp Street, Room 101
Lebanon, IN 46052
765-483-4449
svaughn@co.boone.in.us

HENDRICKS COUNTY SOIL AND WATER CONSERVATION DISTRICT

The Hendricks County SWCD staff review development plans, make recommendations regarding construction and stormwater BMPs, and conduct site inspection for municipal projects within the six MS4 entities in Hendricks County, which cannot be reviewed by the entities themselves. The District does not participate in Rule 5 enforcements. The District is not conducting any volunteer water quality monitoring at this time.

While the Hendricks County SWCD offers intermittent educational events and field days, the District does not have routine, formal, educational program. The District was recently awarded a Clean Water Indiana grant aimed at increasing and improving nutrient management practices. The current Clean Water Indiana grant has a conservation marketing component which will result in promotional materials and workshops for landowners at on-site field locations across the county.

For Rule 5 or stormwater concerns contact:
Jessica Norcross
195 Meadow Drive, Suite 2
Danville, IN 46122
(317) 745-2555

PUTNAM COUNTY SOIL AND WATER CONSERVATION DISTRICT

The Putnam County SWCD offers a variety of land owner assistance programs and technical guidance regarding the implementation of Best Management Practices (BMPs). In addition, the District also oversees the day-to-day management of the Rule 5 Erosion and Sediment Control statewide regulation for Putnam County. In this capacity SWCD staff review development plans, make recommendations regarding construction and stormwater BMPs, and conduct site inspection.

While the Putnam County SWCD offers intermittent educational events and field days, a routine, formal, educational program geared toward elementary students is offered throughout the school year. Volunteer water quality monitoring is somewhat dependent upon current needs or interests in the community.

For general questions regarding conservation initiatives contact: Sue Crafton
For Rule 5 enforcement or stormwater concerns contact: Laura Stearley

All can be reached at:
1007 Mill Pond Lane, Ste. C.
Greencastle, IN 46135
317.65.5716 Ext 3

### 15.1.2 Surveyors & Drainage Boards

County surveyors and drainage boards play a critical role in the implementation of streamside BMPs, as well as potential restoration efforts that may involve the manipulation of current above or below ground drainage infrastructure.

The Indiana Drainage Code of 1965 sets forth the authority to create a Drainage Board in each County. The Drainage Board consists of either the County Commissioners or a citizen board with one Commissioner as a member. The County Surveyor sits on the Board as an Ex-Officio Member. This position is a non-voting position, and the County Surveyor serves as a technical advisor to the Board. The Drainage Board has the authority to construct, maintain, reconstruct or vacate a regulated drain. They may also create new regulated drains if so petitioned by landowners. The Board is in charge of maintaining drains by putting the drain back to its original specifications by dredging, repair tile, clearing, removing obstructions or other work necessary to keep the drain in proper working order. The County surveyors are often the best contact for drainage projects or concerns, or to coordinate with the Drainage Boards.

The Surveyor's Office is also typically task with establishing, reestablishing and recording all section corners throughout the county; supervising all civil engineering work of the county; recording the location of legal surveys; supervising construction, reconstruction and maintenance of drains and ditches; developing drainage studies and specifications, issues drainage related permits; and calculating drainage assessments.

Many of the streams and ditches in the watershed are official 'regulated drains' and are therefore under the authority of the drainage boards and surveyors. Any project proposed along these waterways should be coordinated with the appropriate County Surveyor.

BOONE COUNTY
Kenny Hedge
County Surveyor
116 West Washington Street
Lebanon, IN 46052
765-483-4444
khedge@co.boone.in.us
The board meets the third Monday of the month at 8:30am in the Boone County Office Building.

HENDRICKS COUNTY
David Gaston
355 S. Washington St. #214
Danville, IN 46122
317-745-9237
Drainage Board meetings: 2nd and 4th Tuesday - 8:30am at the Hendricks County Government Center

PUTNAM COUNTY
David Penturf
1W. Washington St. Rm. 43
Greencastle, IN 46135
(765) 653-5603
Putnam County does not have an official drainage board therefore all drainage concerns fall to the commissioners. They meet on the first Monday at 9:00am and third Monday at 6:00pm at the Putnam County Courthouse Annex

### 15.1.3 Planning and Zoning Authorities

County-wide Comprehensive Plans can provide a significant amount of information on both natural resources in an area, as well as population statistics, traffic plans, and current and future land use zoning. Such zoning designations, if enforced, often drive where future residential and commercial/industrial growth will occur. The authority to rezone land into different land use categories and the power to grant variances from local ordinances related to development, often lie with local Zoning Boards or Plan Commissions.

BOONE COUNTY
The Boone County Area Plan Commission (APC) is in the process of completing a new comprehensive plan. An open house to discuss and view the new plan is set for September 12, 2008, 6:30pm at the County Fairgrounds. The Board of Zoning Appeals (BZA) is task with granting variances or special exceptions form the zoning ordinance. In addition, the BZA and the APC work together to administer land use and zoning regulations for the county; issue building permits; issues addressed for new homes and businesses; and maintain census data for the county. The APC meets the first Wednesday of each month at 7:00 pm in the Boone County Government Building – Lamar Room. The BZA meets the last Wednesday of each month at 7:00pm in the Boone County Government Building – Lamar Room. The best contact for watershed land use concerns related to development or zoning in Boone County is:

Steve Niblick
116 W Washington St.
Lebanon, IN 46052
(765) 482-3821
sniblick@co.boone.in.us

HENDRICKS COUNTY

Hendricks County has a comprehensive plan that was adopted in 2006. Printed copies are available. There is not a current schedule to amend the comp plan, but discussions of doing so have recently surfaced. The County Commissioners approve any rezoning requests upon a recommendation by the County Plan Commission. The Plan Commission meets monthly on the second Tuesday of the month at 6:30 p.m. in Rooms 4 and 5 of the Hendricks County Government Center. There is also a County Board of Zoning Appeals that meets on the third Monday of the month at 7:30 p.m. in Rooms 4 and 5 of the Hendricks County Government Center. The best contact for watershed land use concerns related to development or zoning in Hendricks County is:

Hendricks County Planning and Building
355 S. Washington Street #212
Danville, IN 46122
Planning Phone: (317) 745-9254
Zoning Phone: (317) 745-9243
www.co.hendricks.in.us

PUTNAM COUNTY

Putnam County's most recent Comprehensive Plan is dated 2007. The final draft was only recently accepted; therefore there are no plans for any near future updates. Putnam County is currently in the process of updating the Zoning and Subdivision Control Ordinances. The Plan Commission makes recommendations for rezoning and the County Commissioners make the final determination. There is one city in Putnam County that has up to a two mile jurisdictional area outside its city limits and an exact parcel would need to be known in order to make the determination as to who has jurisdiction. There is also Board of Zoning Appeals (BZA). The Plan Commission meets the second Thursday of the month at 5:30pm if there are agenda items to address. The BZA meets the second Monday at 7:30pm. The best contact for watershed land use concerns related to development or zoning in Putnam County is:

Kim Hyten, Plan Director
209 W. Liberty St., Room 3
Greencastle, Indiana 46135
Phone: (765) 653-5727
FAX: (765) 653-0231
pcplanning@airhop.com

### 15.1.4 Health Departments

BOONE COUNTY

The Boone County Health Department employs four Environmental Health Specialists. The focus of the Environmental Division of the Health Department is the prevention of disease, while ensuring a safe environment. Concern for environmental health has increased along with population growth, urbanization, advanced technology, industrialization and modern agriculture methods. Assessment and reduction of human health risks is accomplished through investigations, inspections and regulatory enforcement. Frequently, investigations and inspections are conducted with other local and state government agencies and environmental organizations.

Food safety is assured through inspections of nearly 180 food establishments in Boone County. Water quality inspections of public and semi-public swimming pools and spas are performed. Information on indoor air quality and radon is available in our office. In addition, a certified lead inspector provides information on lead hazards.

Septic system installation is a regulated activity in Boone County. After a process of plan review, septic permits are issued by the Health Department and inspected before final approval. All new and repaired residential drinking water wells are permitted, inspected, and tested. General environmental health complaints and housing complaints are investigated if they involve any condition that transmit, generate or promote disease. The best contact for watershed septic system concerns is:

Sharon Adams
Environmental Health Department
116 W Washington Street, B201
Lebanon, IN 46052
Phone: (765) 483-4458
Fax: (765) 483-5243
shadams@co.boone.in.us

HENDRICKS COUNTY

The Hendricks County Health Department does not conduct routine water quality monitoring. The Department provides voluntary training for septic system installers. Conversations with representatives from the Health Department indicate that one of the primary concerns in rural areas is septic discharges into field tiles. The Department has geographically located all improved properties with undocumented/unknown wastewater disposal as well as those with permitted system information in order to document problem areas; however, they are in need of funding to implement corrections in concentrated problem areas. The best contact for watershed septic system concerns is:

Cathy Grindstaff, REHS
Environmental Health
Hendricks County Government Center
355 S. Washington St., #210
Danville, Indiana 46122
Phone: (317) 745-9217

More information can be found online at:
http://www.co.hendricks.in.us/GovernmentCenter/HealthDepartment/EnvironmentalHealth/tabid/82/Default.aspx

PUTNAM COUNTY

The Putnam County Health Department plays an important role in septic systems siting, education, and enforcement. The Putnam County Health Department does not conduct regular water quality monitoring; however, they will collect and analyze samples based on public complaints. According to Health Department staff, no notable septic systems concern areas exist in the watershed due to the earlier sewer installation around the lakes. If significant development were to occur within the watershed, consideration would need to be given to the capacity of the receiving wastewater treatment plant and/or the soil suitability in the area. The best contact for watershed septic system concerns is:

Dr. Robert Heavin
Greencastle Courthouse Annex
209 West Liberty Street
Greencastle, IN 46135
Phone: (765) 653-5210

## 15.2 State & Federal Government Offices

### 15.2.1 IDNR & IDEM

The Indiana Department of Natural Resources (IDNR) and the Indiana Department of Environmental Management (IDEM) have a variety of programs and staff dedicated to water quality assessments and watershed planning initiatives. The most relevant contacts at these agencies to assist local leaders in water quality planning efforts are listed below. While there are countless specialists at these agencies, the below staff should be able to guide local questions to appropriate personnel.

Indiana Department of Natural Resources
Division of Fish & Wildlife – Lake & River Enhancement Program (LARE)
Mr. Kent Tracey
1353 S. Governors Dr.
Columbia City, IN 46725
Phone: (260) 244-7470

Indiana Department of Natural Resources
Division of Nature Preserves
Thomas O. Swinford
Regional Ecologist, Central Indiana
402 W. Washington St. Rm. W267
Indianapolis IN
Desk: 317/233-4849
Mobile: 317/697-5508

Indiana Department of Environmental Management
Office of Water Quality
Ms. Bonnie Elifritz, Watershed Specialist
100 N. Senate Ave.
Indianapolis, IN 46206
(317) 234-0922

### 15.2.2 Indiana State Department of Agriculture (ISDA)

The Division of Soil Conservation belongs to the Indiana Conservation Partnership; however is situated in the State Department of Agriculture (ISDA). As part of the Partnership, ISDA provides technical, educational, and financial assistance to citizens to solve erosion and sediment-related problems occurring on the land or impacting public waters. The Division of Soil Conservation is divided into Conservation Implementation Teams (CIT) that cover specific counties. These teams can deliver advice to landowners regarding best management practices, assist with engineering design, and secure/coordinate associated project permits and cost share amounts.

CIT Leader for Hendricks and Boone Counties is:
Boone County Service Center serves Hendricks County
Ruth Montgomery - USDA/NRCS
801 West Pearl Street
Lebanon, IN 46052
(765)482-6355 ext. 3
ruth.montgomery@in.usda.gov

CIT Leader for Putnam County is:
William Elliot
1007 Mill Pond Lane, Ste. C
Greencastle, IN 46135
(765)653-5716 ext. 8
william.elliot@in.usda.gov

### 15.2.3 National Resources Conservation Service (NRCS)

The NRCS is a Federal agency that works with land owners and managers to conserve their soil, water, and other natural resources. NRCS employees provide technical assistance based on a customer's specific needs in such areas as animal husbandry and clean water, ecological sciences, engineering, resource economics, and social sciences. They also provide financial assistance for many conservation activities. The NRCS programs are all voluntary participation programs.

District Conservationists for the counties are listed below.

Boone County
Angela Garrison
801 W Pearl Street, Ste C.
Lebanon, IN 46052
765-482-6355

Hendricks County
Henry Wallis
195 Meadows Drive, Ste 1
Danville, IN 46122
317-745-2555

Putnam County
Matt Jarvis
1007 Millpond Lane, Ste C.
Greencastle, IN 46135
765-653-5716 ext 3

### 15.2.4 United States Geological Survey (USGS)

The USGS is a multi-disciplinary science organization focused on biology, geography, geology, geospatial information, and water. They work to study the study of the landscape, our natural resources, and the natural hazards that threaten us.

Jeffrey W. Frey
5957 Lakeside Boulevard
Indianapolis, IN 46278
(317)290-3333 ext.151
jwfrey@usgs.gov

## 15.3 Local Non-Profit Organizations

### 15.3.1 Resource Conservation and Development Council (RC&D)

Resource Conservation and Development Councils (RC&D) are non-profit organizations established to address natural resource needs and cultivate opportunities in economic, environmental, and social areas. The primary natural resource focus is on air, water, land, woods, plants, and wildlife. The combined efforts of the community and volunteers look to achieve four primary goals:

1. Promote Better Woodland Management
2. Balance Rural and Urban Land Use Needs
3. Develop Partnerships to Address Water Quality and Quantity
4. Increase Community Involvement in Natural Concerns

Two RC&Ds serve the counties of the Big Walnut Creek Watershed: Hoosier Heartland RC&D and Sycamore Trails RC&D.

Hoosier Heartland RC&D

The Hoosier Heartland RC&D serves Boone, Brown, Hamilton, Hancock, Hendricks, Johnson, Marion, Monroe, Morgan, and Shelby Counties. The Hoosier Heartland RC&D Council can be contacted at:

Hoosier Heartland RC&D Council
6041 Lakeside Blvd.
Indianapolis, IN 46278-1989
Phone: (317)290-3250
Fax: (317)290-3150
Email: hhrcd@hhrcd.org
Web: www.hhrcd.org

Sycamore Trails RC&D

The Sycamore Trails Resource Conservation and Development Council was incorporated in 1987 and serves Clay, Fountain, Montgomery, Owen, Parke, Putnam, Sullivan, Vermillion, Vigo Counties. The Sycamore Trails RC&D Council can be contacted at:

Sycamore Trails RC&D Council
1007 Mill Pond Lane, Ste. B
Greencastle, IN 46135
Phone (765) 653-9785
strcd@sycamoretrails.org

### 15.3.2 Central Indiana Land Trust, Inc. (CILTI)

Land Trusts can be invaluable organizations in efforts to conserve and restore important lands. Hand-in hand planning with land trusts can help assist in region-wide corridor connectivity and large-scale conservation goals for individual species or habitat types. Land trust can also often assist conservation groups by being the land holding entity and using its volunteers to maintain the property long-term.

The CILTI Land Trust is a non-profit organization aimed at preservation of important natural lands in north-east Indiana. CILTI was incorporated exclusively for charitable, educational and scientific purposes. It has five general purposes:

1. As a part of the continued growth of the communities in which it operates, as a land trust to acquire interests in and to preserve natural areas and to discourage unnecessary development of natural areas.
2. Impartially to educate communities as to the value to them of the preservation of natural areas.
3. To promote the knowledge and appreciation of natural areas as living museums.
4. To develop such scientific, educational and public recreational uses of natural areas as are consistent with their preservation as living museums.
5. To cooperate with and to encourage other organizations and individuals in carrying out the foregoing activities.

CILTI can be contacted at:

Central Indiana Land Trust, Inc.
Heather Bacher
324 W. Morris St., Ste. 210
Indianapolis, IN 46225
Phone: (317) 631-LAND (5263)
www.CILTI.org

### 15.3.3 The Nature Conservancy (TNC)

The Nature Conservancy's mission is to preserve the plants, animals and natural communities that represent the diversity of the life on Earth by protecting the lands and waters they need to survive.

Indiana Field Office
1505 N. Delaware Street, Suite 200
Indianapolis, IN 46202
Phone: (317) 951-8818
Fax: (317) 917-2478
Chip Sutton, Director of Communications

Tippecanoe River Project Office
436 Northwest Street
Winamac, IN 46996
Phone: (574) 946-7491
Chad Watts, Program Manager
www.nature.org/indiana

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Dufour R.L. (Biological Studies Section, Assessment Branch, Office of Water Management, Indiana Department of Environmental Management). 1997. A preliminary appraisal of the biological integrity of Indiana streams in the West Fork White River watershed using fish communities. Report Nr IDEM/32/03/003/1997. 30p.

Dufour, R.L. 2001. DRAFT: Fish Community Assessment of the Middle and Lower Wabash River, Kankakee River, and Iroquois River Basins, Indiana, 1999. Written for the Indiana Department of Environmental Management, Office of Water Quality, Assessment Branch, Biological Studies Section, Indianapolis, Indiana. IDEM 032/03/003/2001.

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# APPENDIX A
ENVIRONMENTAL FIGURES

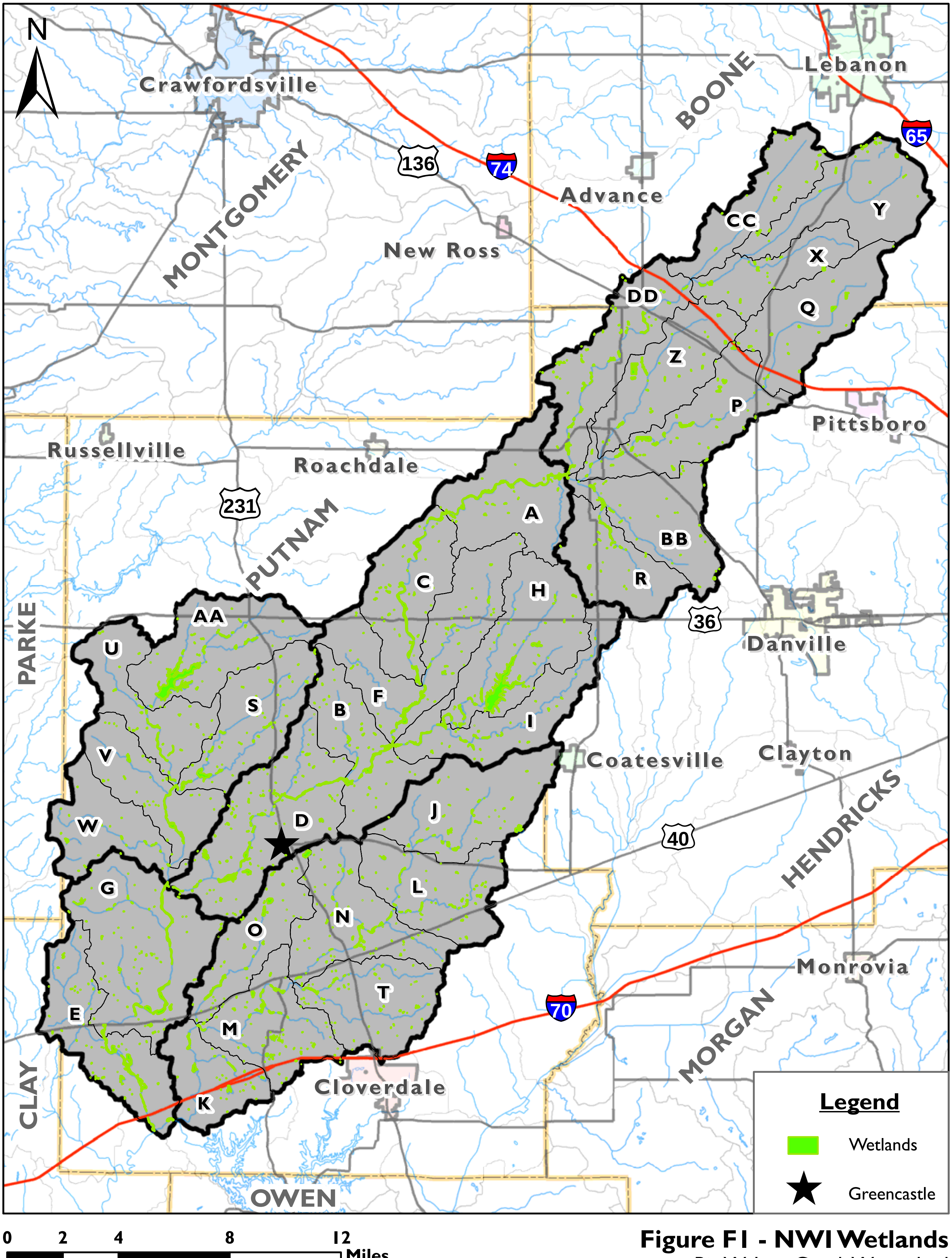


**Figure F1 - NWI Wetlands**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

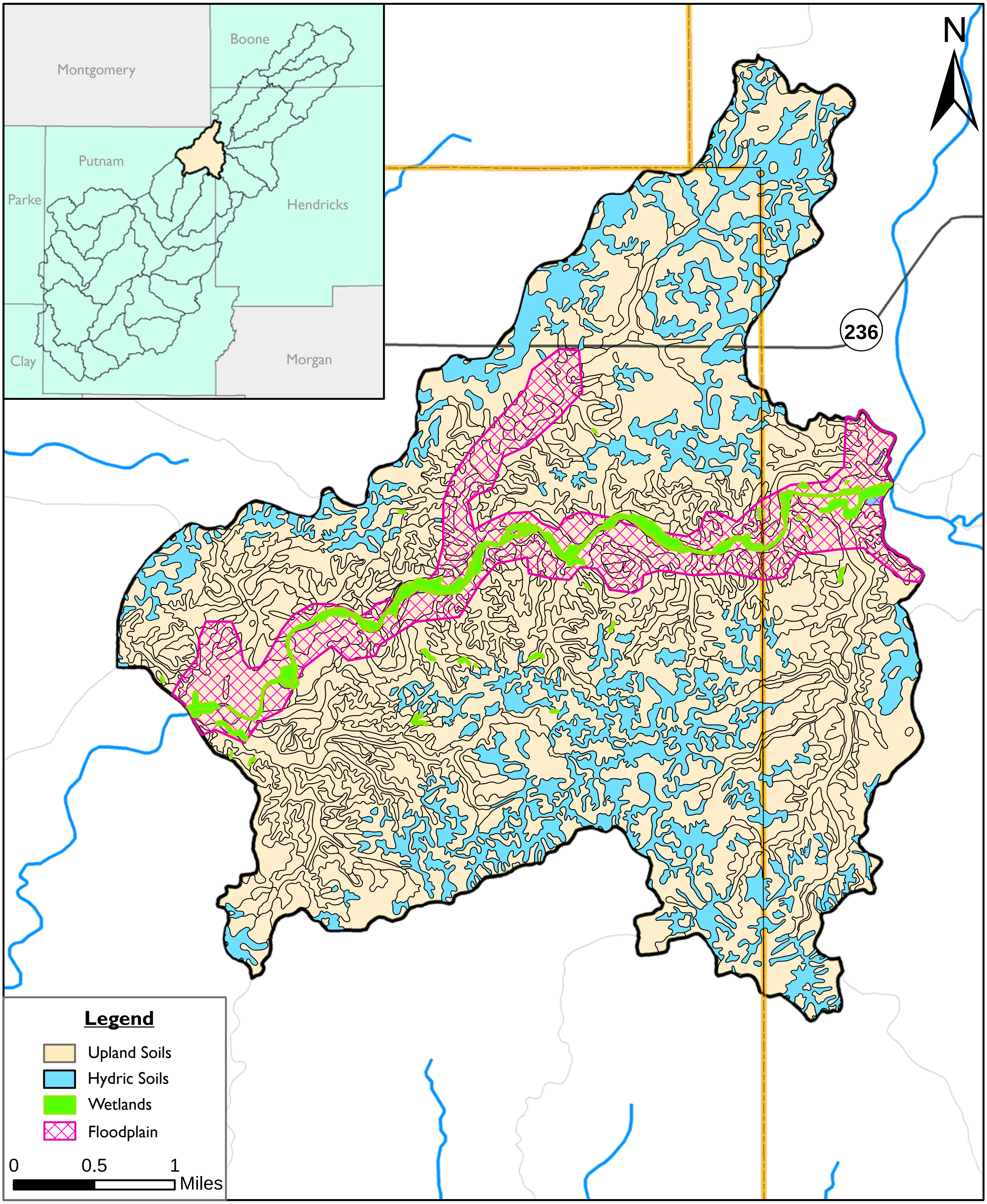


**Figure F2 - Soils, Floodplains, and Wetlands**
**A - Big Walnut Creek - Barnard**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

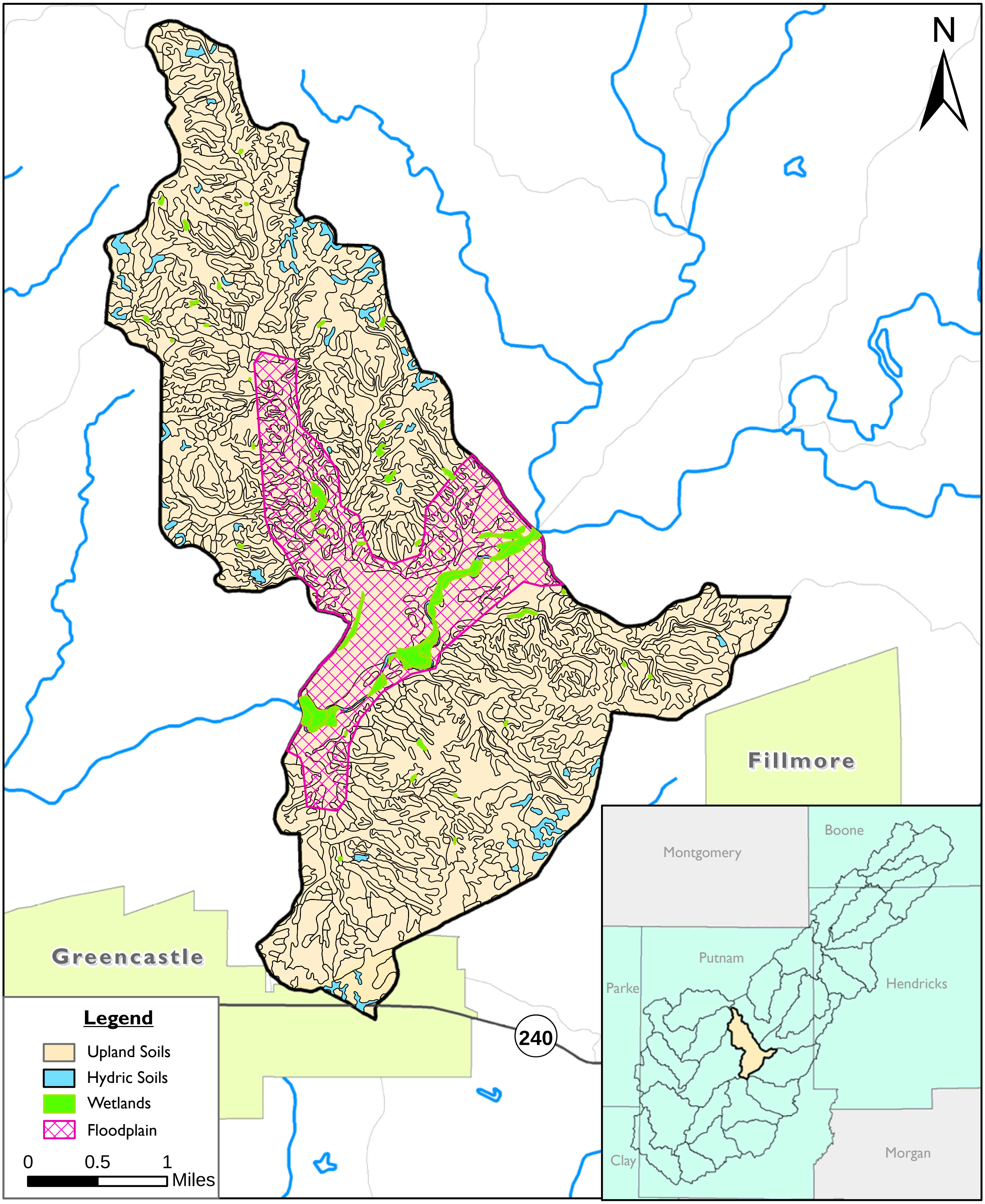


**Figure F3- Soils, Floodplains, and Wetlands**
**B - Big Walnut Creek - Dry Branch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

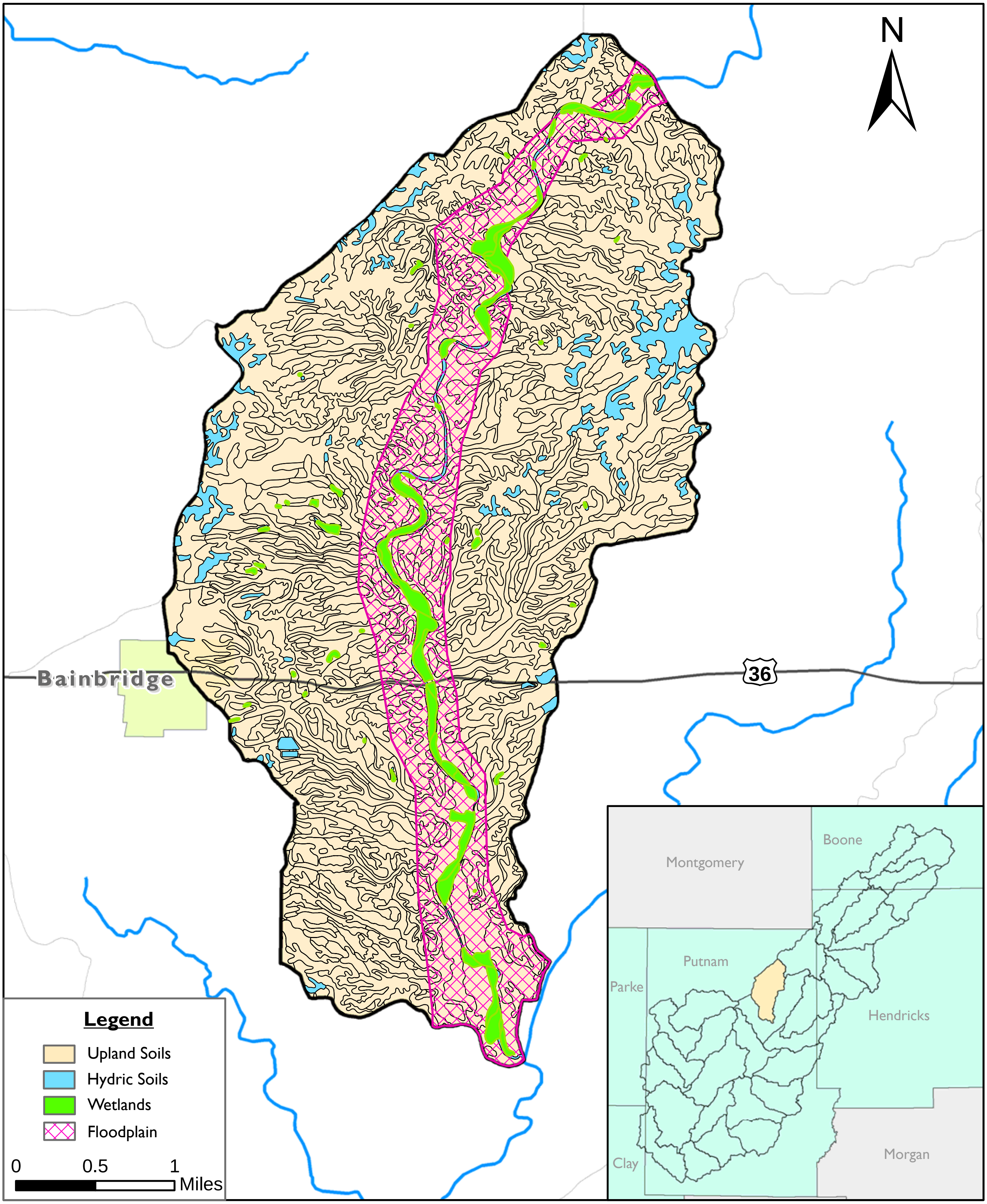


**Figure F4 - Soils, Floodplains, and Wetlands**
**C - Big Walnut Creek - Ernie Pyle Memorial Hwy**
**14-HUC Watershed**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

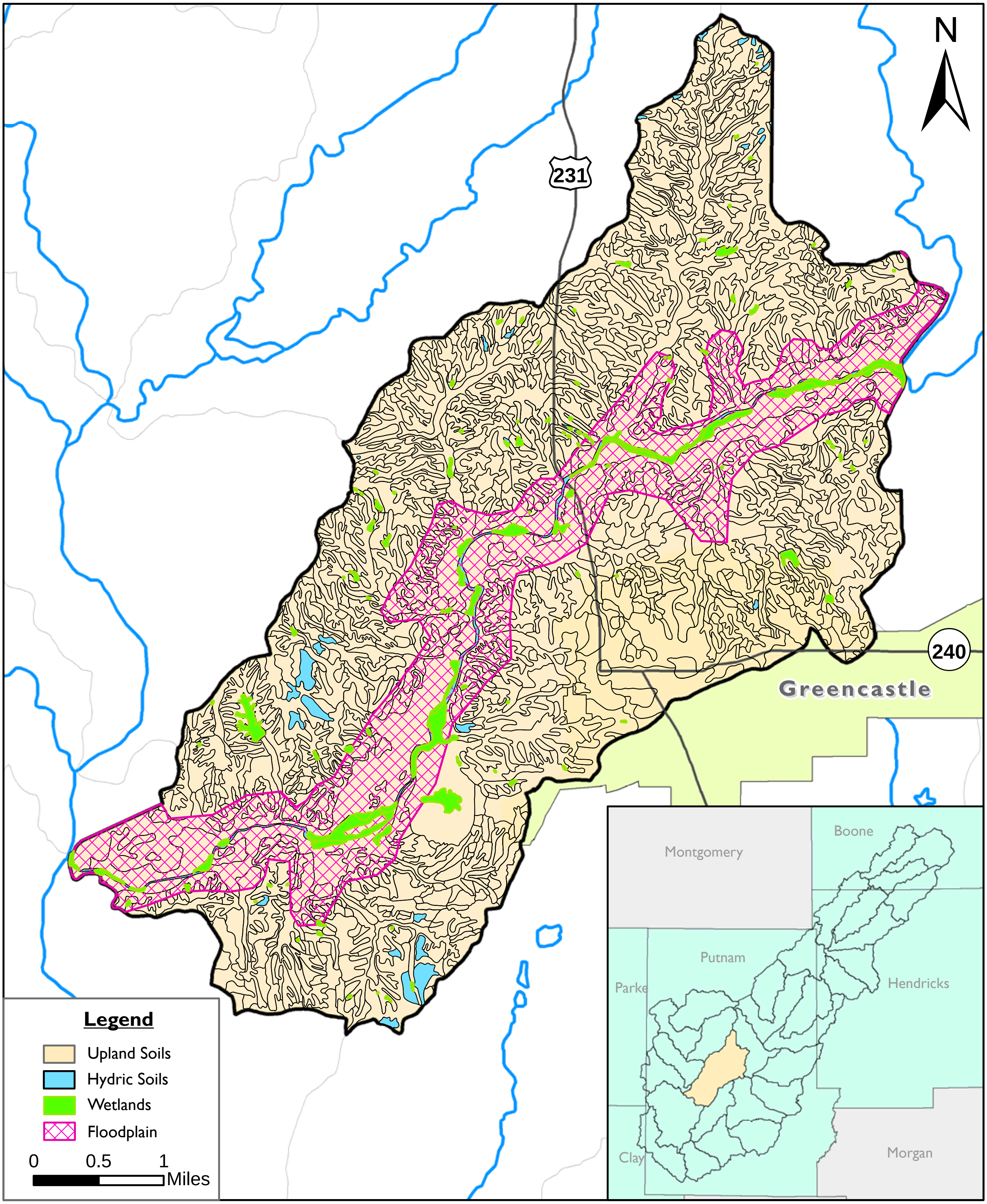


**Figure F5 - Soils, Floodplains, and Wetlands**
**D - Big Walnut Creek - Greencastle**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

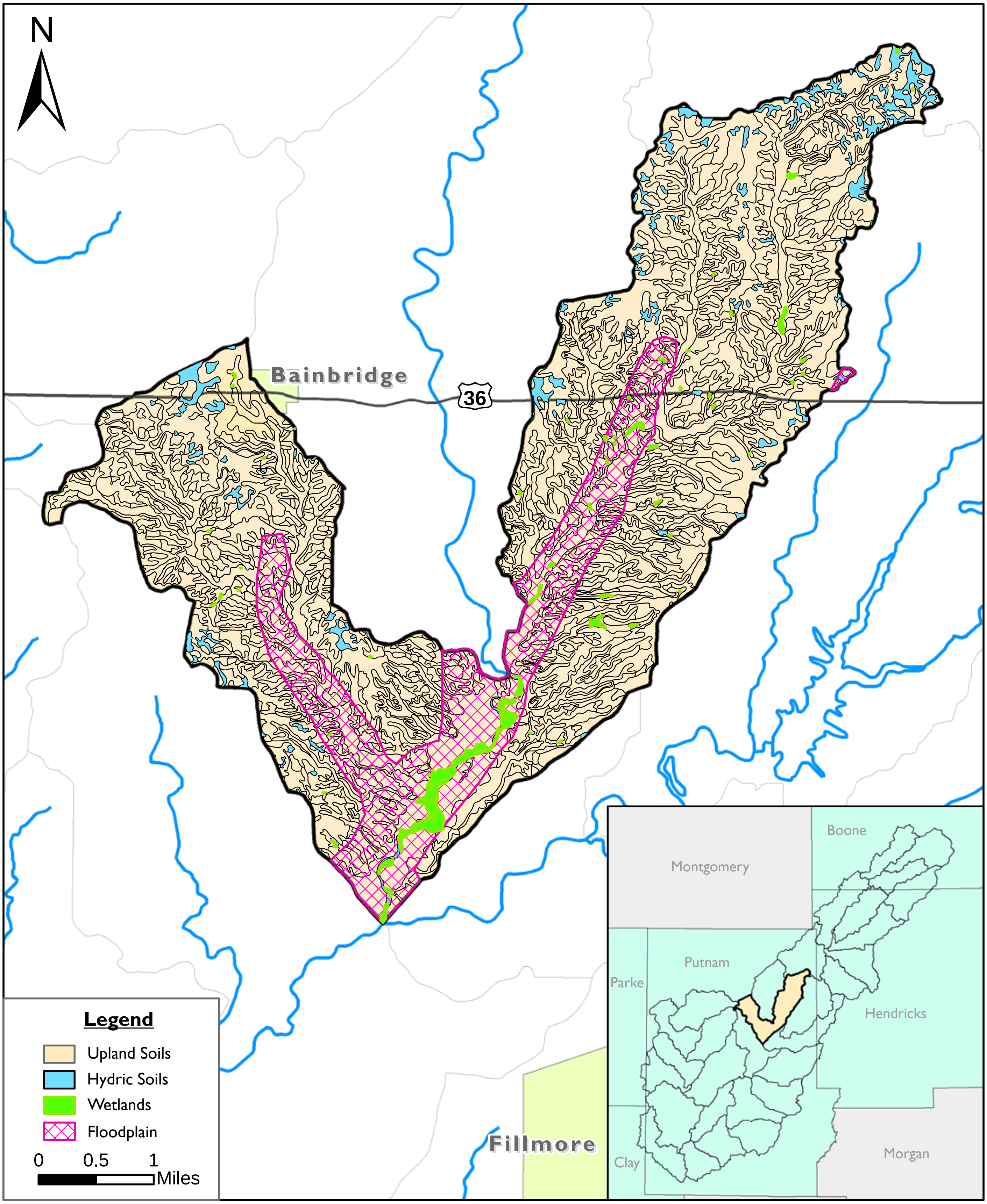


**Figure F6 - Soils, Floodplains, and Wetlands**
**F - Big Walnut Creek - Plum Creek/Bledsoe Branch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

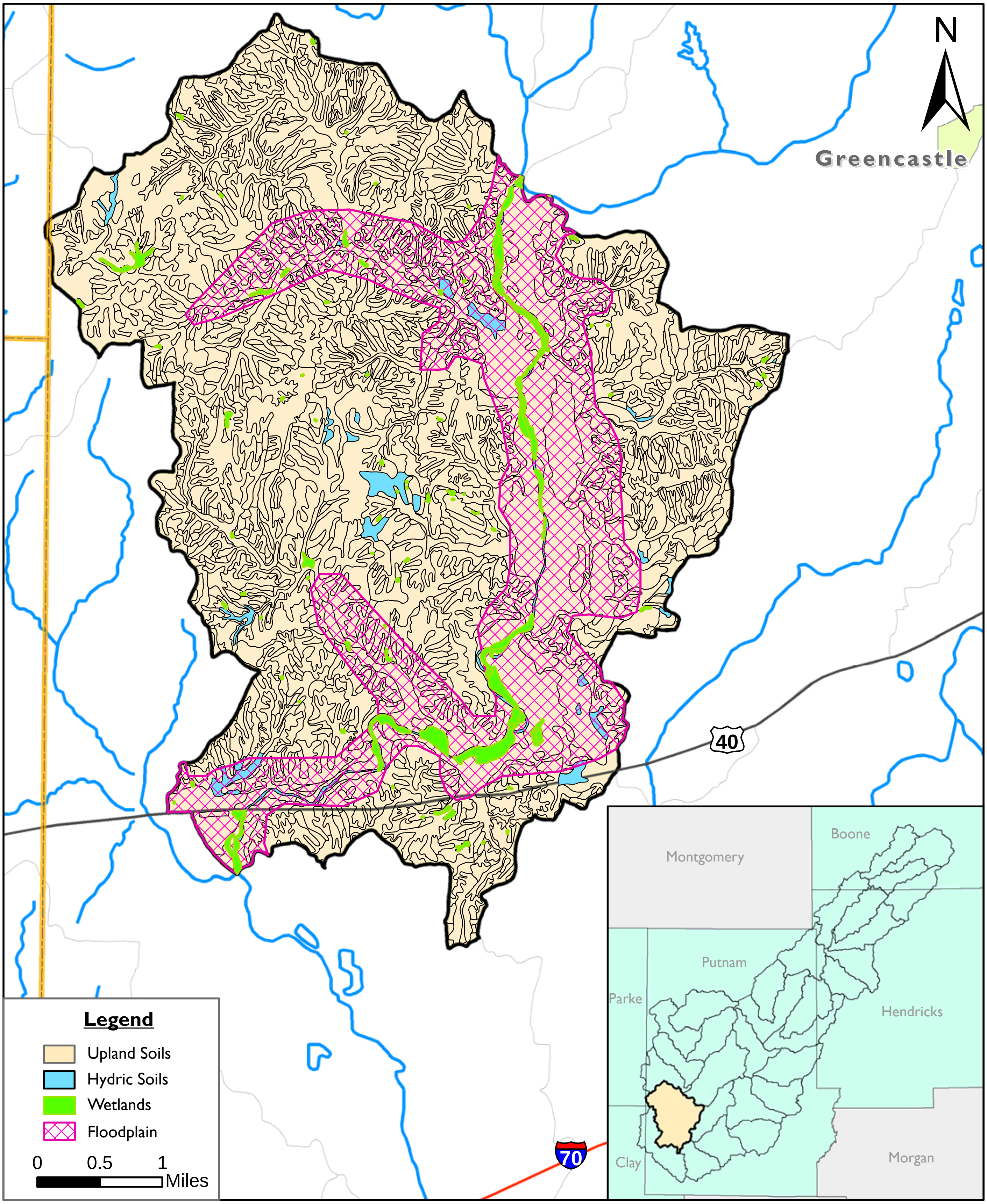


**Figure F7 - Soils, Floodplains, and Wetlands**
**G - Big Walnut Creek - Snake Creek/Maiden Run**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

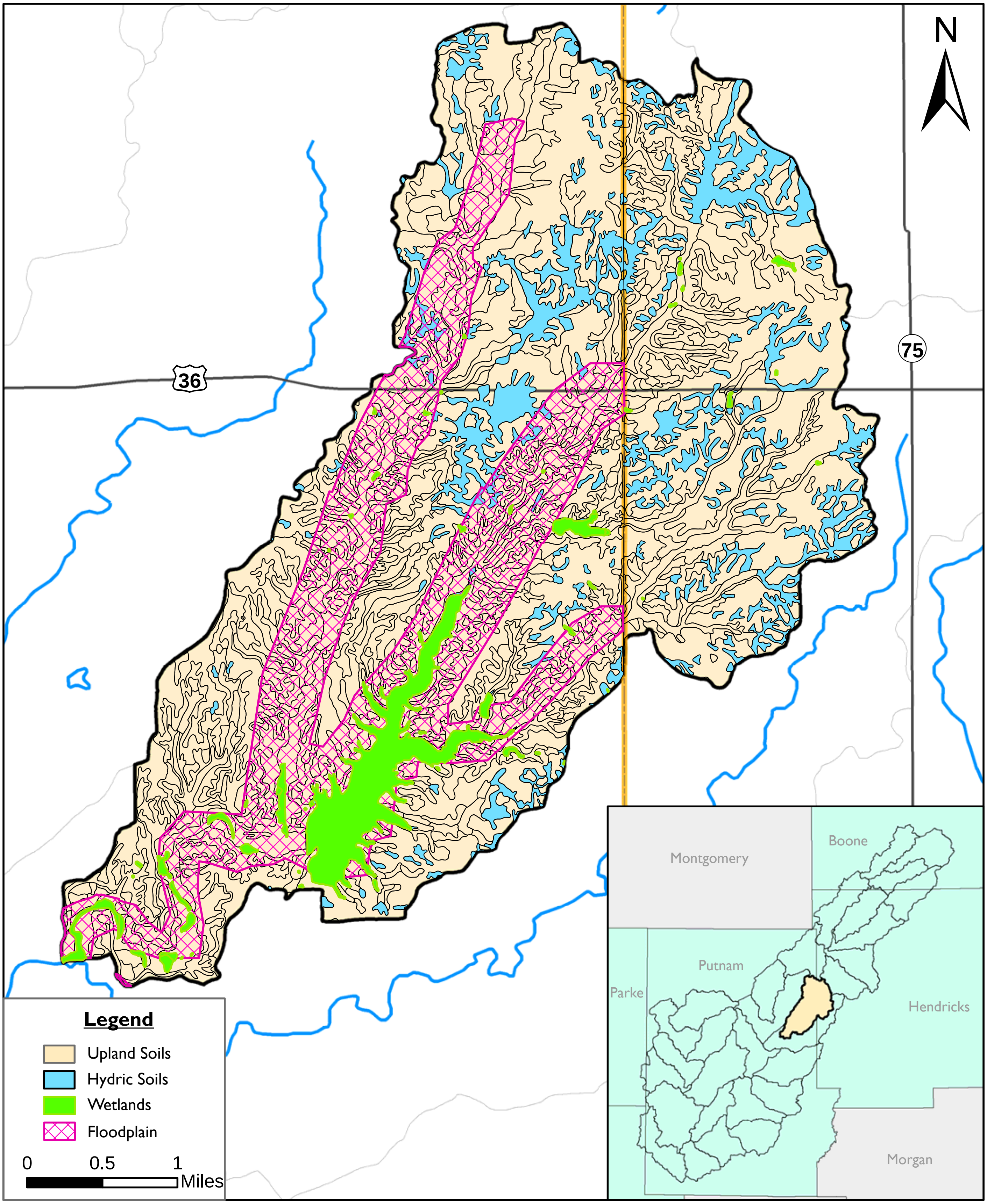


**Figure F8 - Soils, Floodplains, and Wetlands**
**H - Clear Creek - Headwaters (Putnam)**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

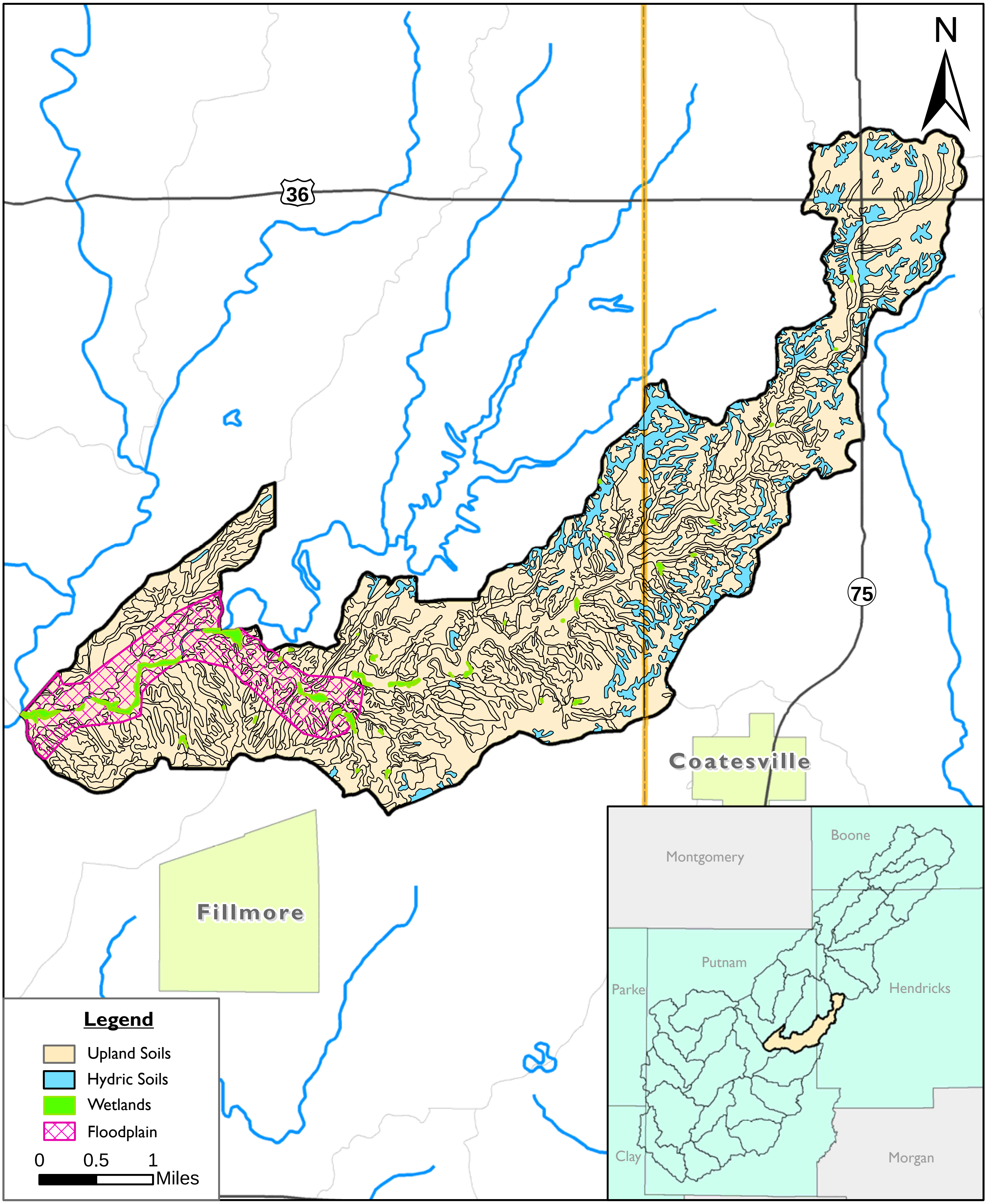


**Figure F9 - Soils, Floodplains, and Wetlands**
**1 - Clear Creek - Miller Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

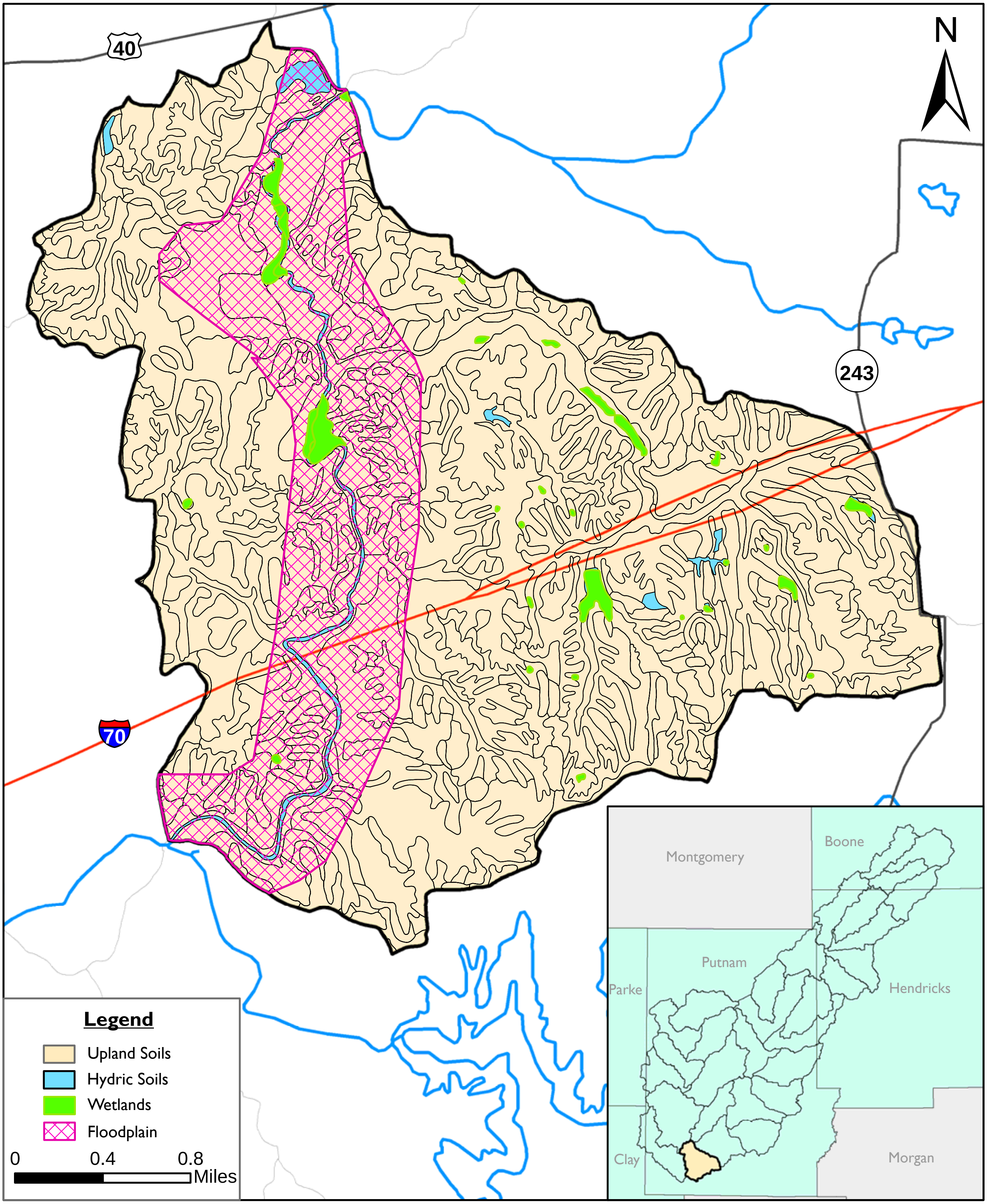


**Figure F10 - Soils, Floodplains, and Wetlands**
**K - Deer Creek - Leatherwood Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

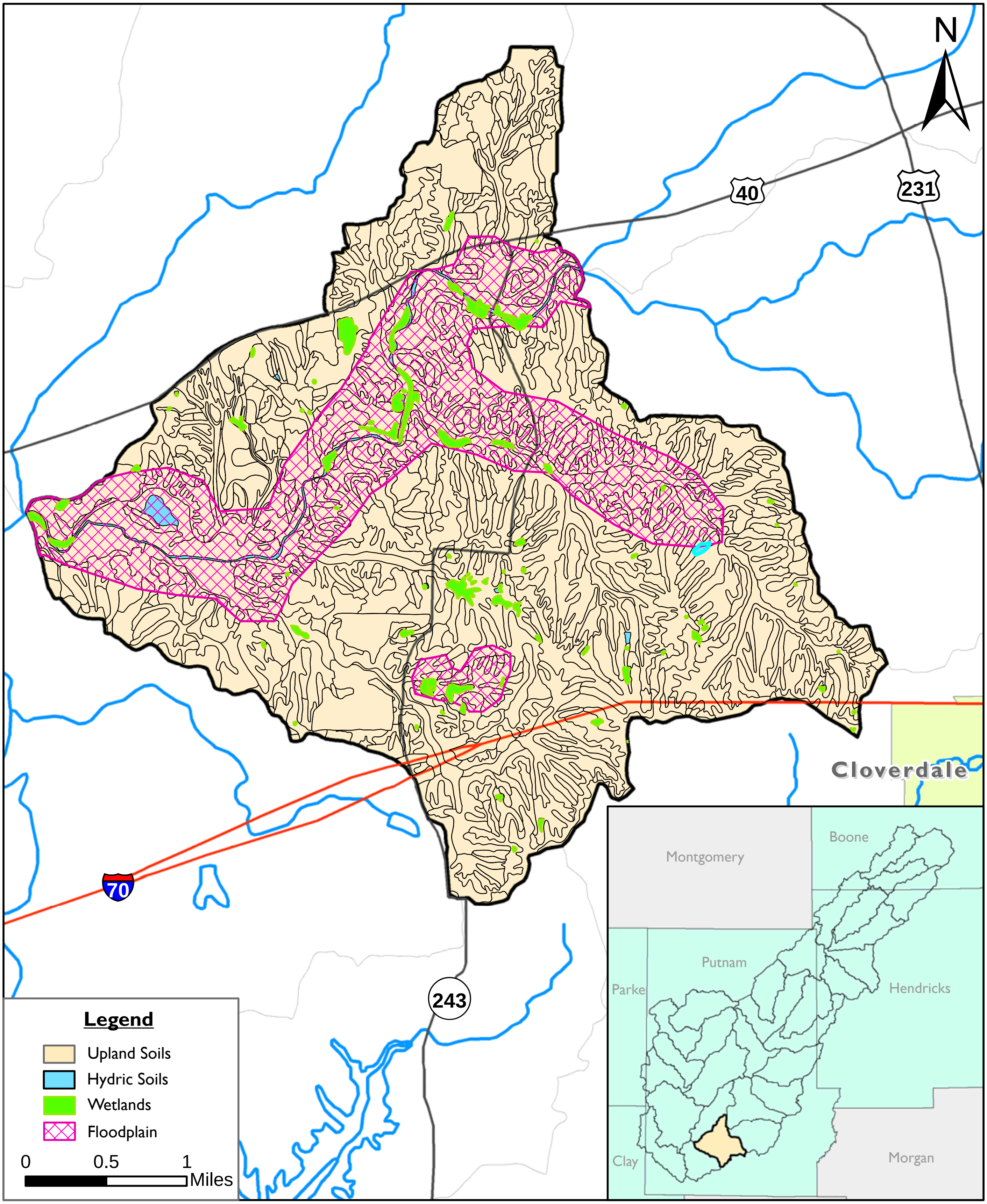


**Figure F11 - Soils, Floodplains, and Wetlands**
**M - Deer Creek - Mosquito Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

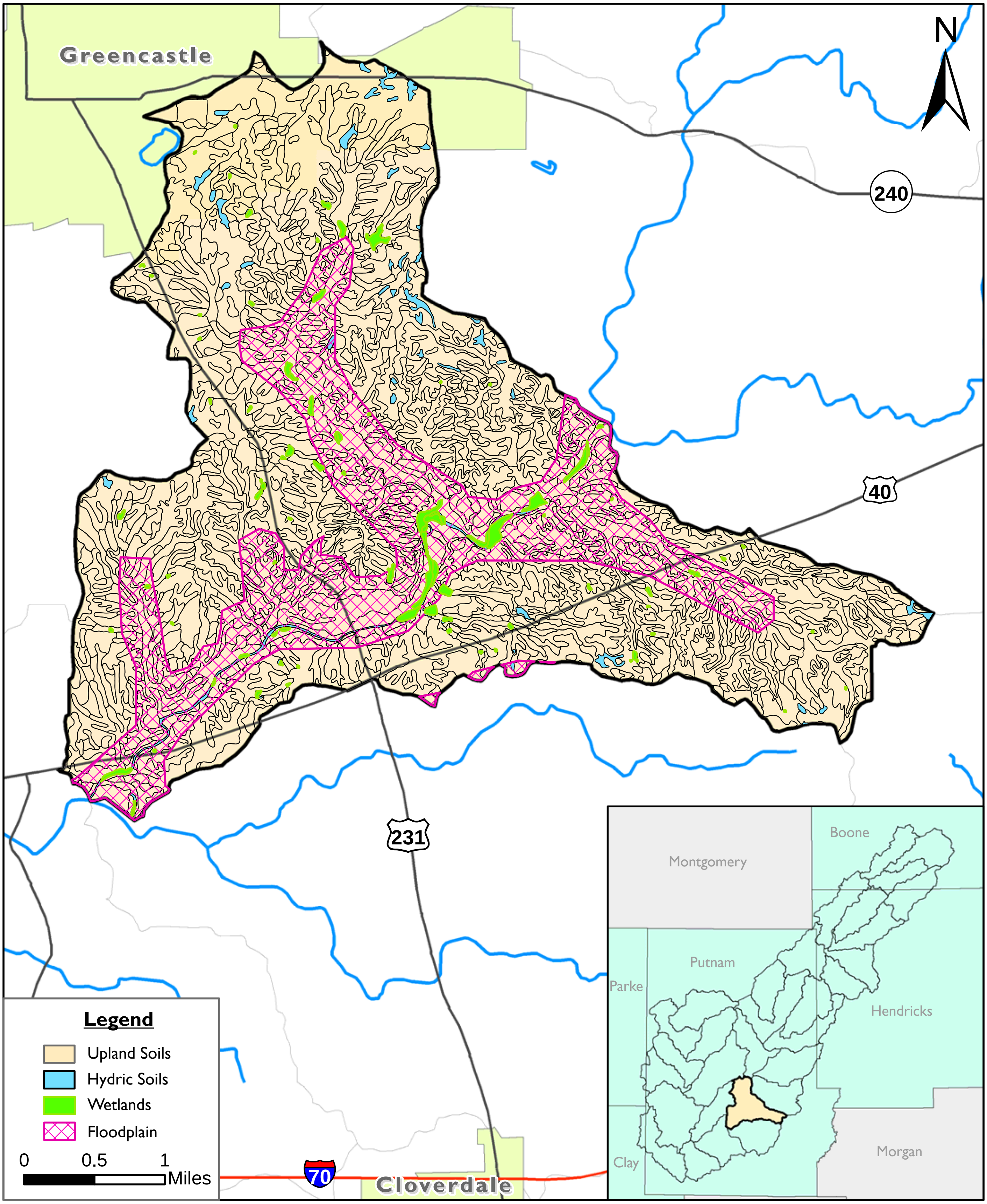


**Figure F12 - Soils, Floodplains, and Wetlands**
**N - Deer Creek - Owl Branch**
**14-HUC Watershed**

Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

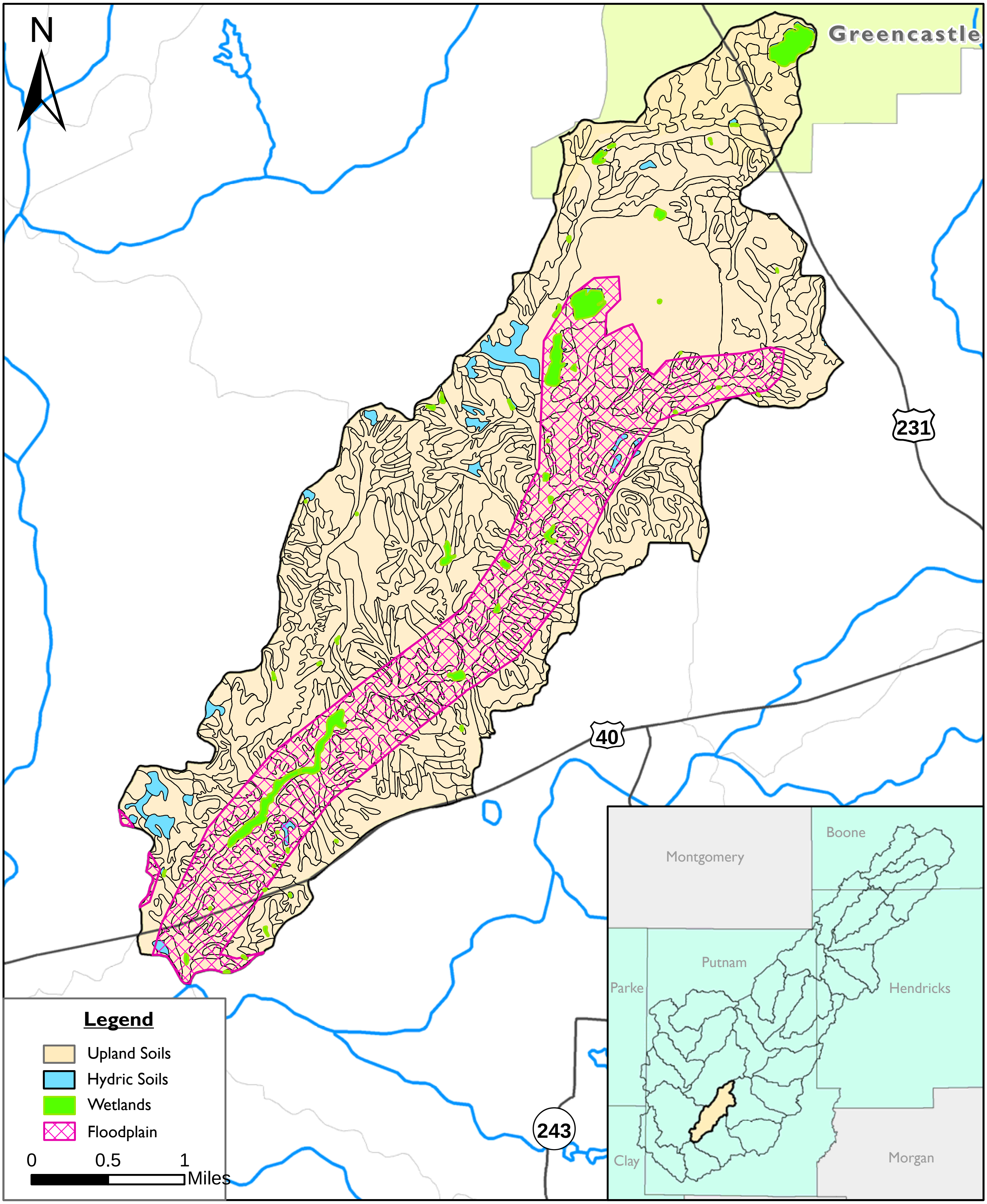


**Figure F13 - Soils, Floodplains, and Wetlands**
**O - Deweese Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

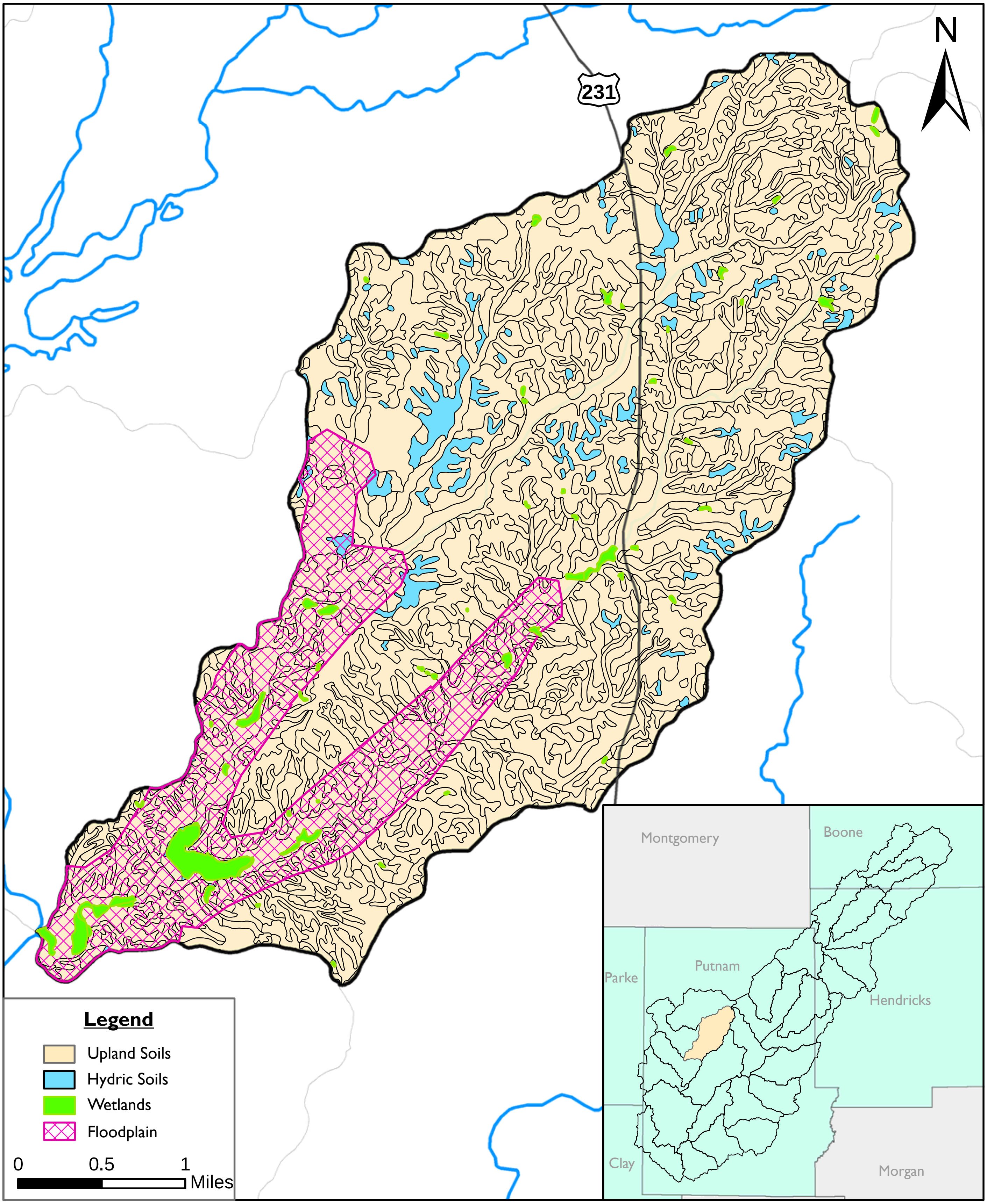


**Figure F14 - Soils, Floodplains, and Wetlands**
**S - Jones Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

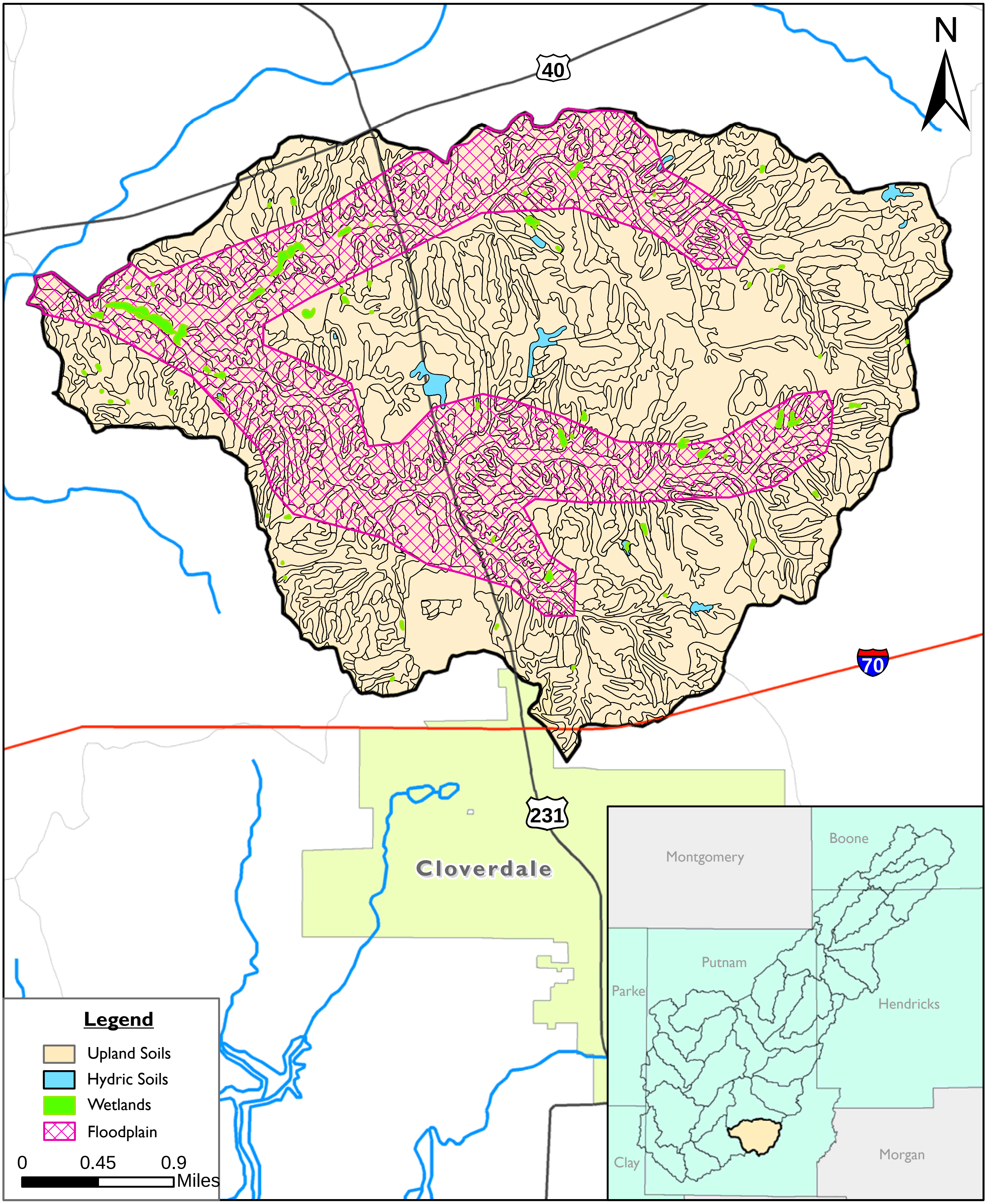


**Figure F15 - Soils, Floodplains, and Wetlands**
**T - Limestone Creek (Putnam)**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

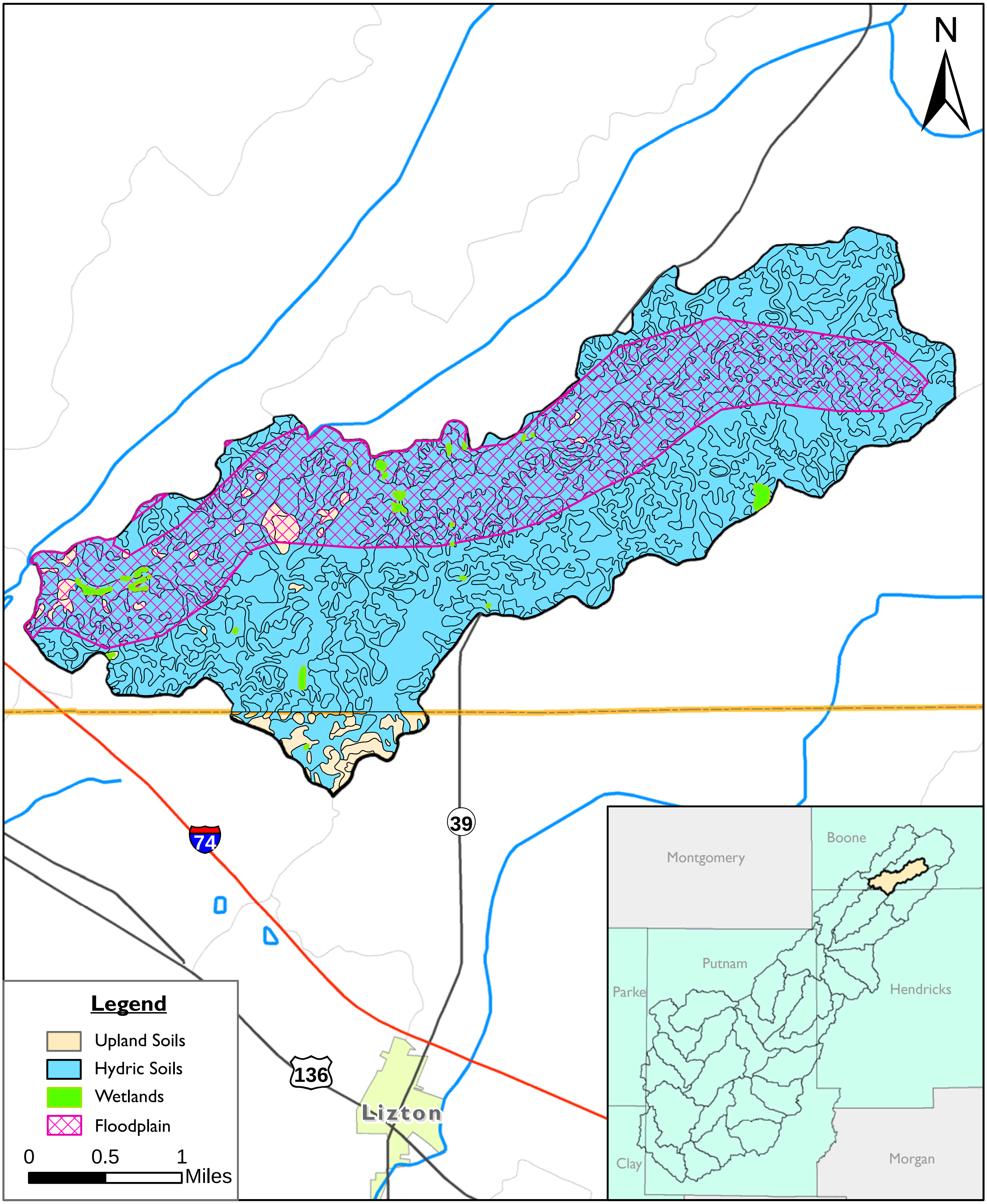


**Figure F16 - Soils, Floodplain, and Wetlands**
**X - Main Edlin Ditch - Grassy Branch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

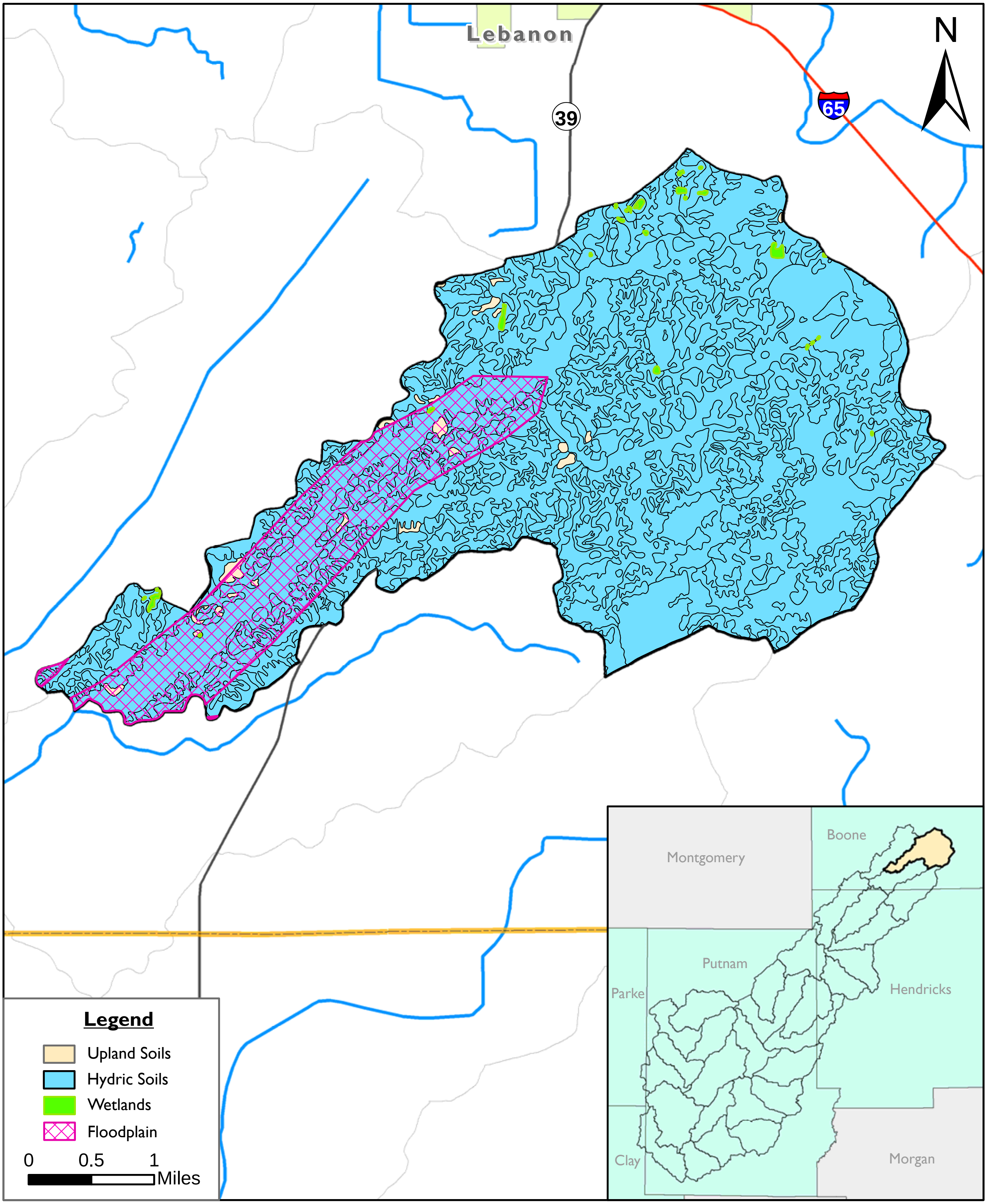


**Figure F17 - Soils, Floodplains, and Wetlands**
**Y - Main Edlin Ditch - Smith Ditch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

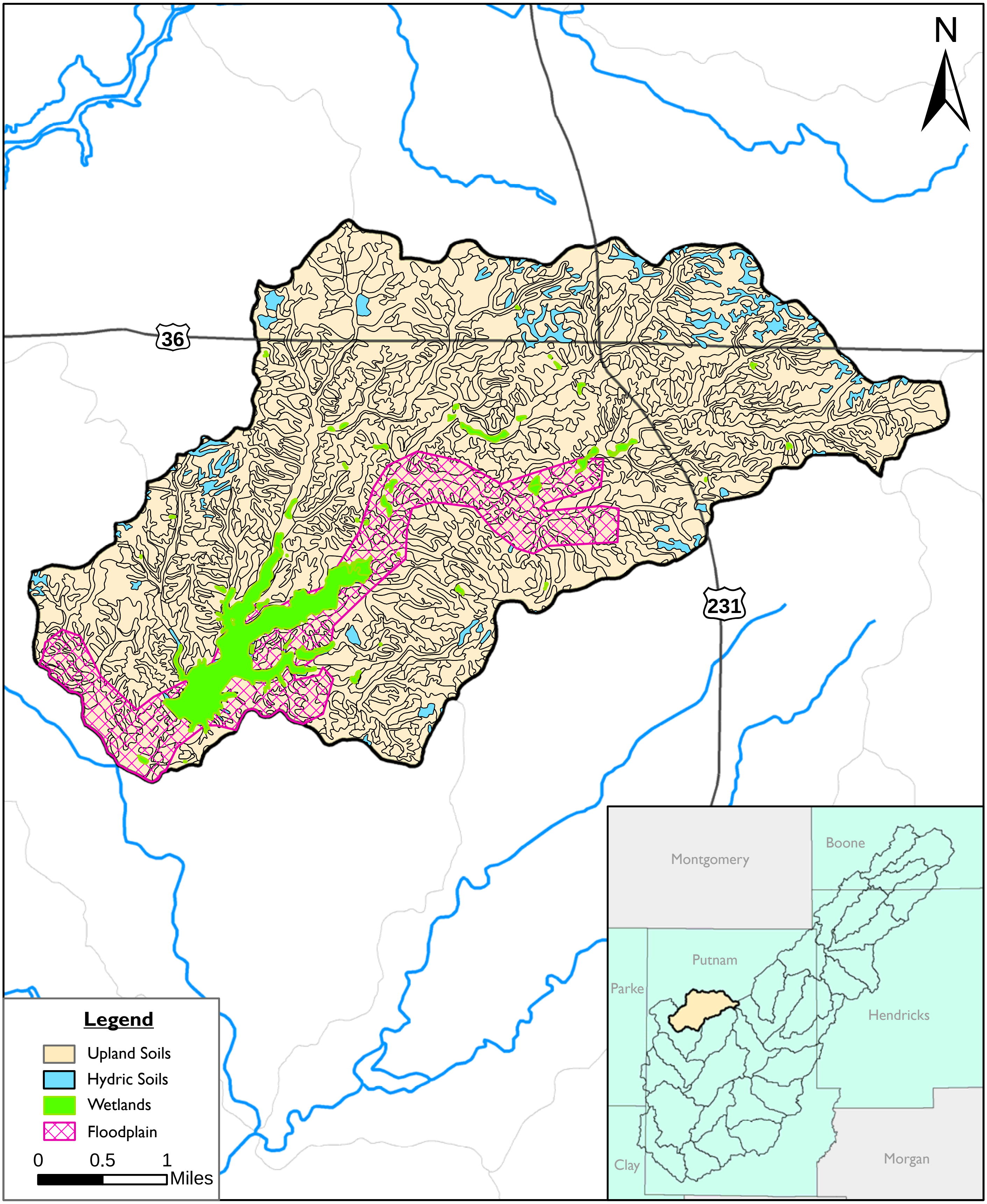


**Figure F18- Soils, Floodplains, and Wetlands**
**AA - Owl Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

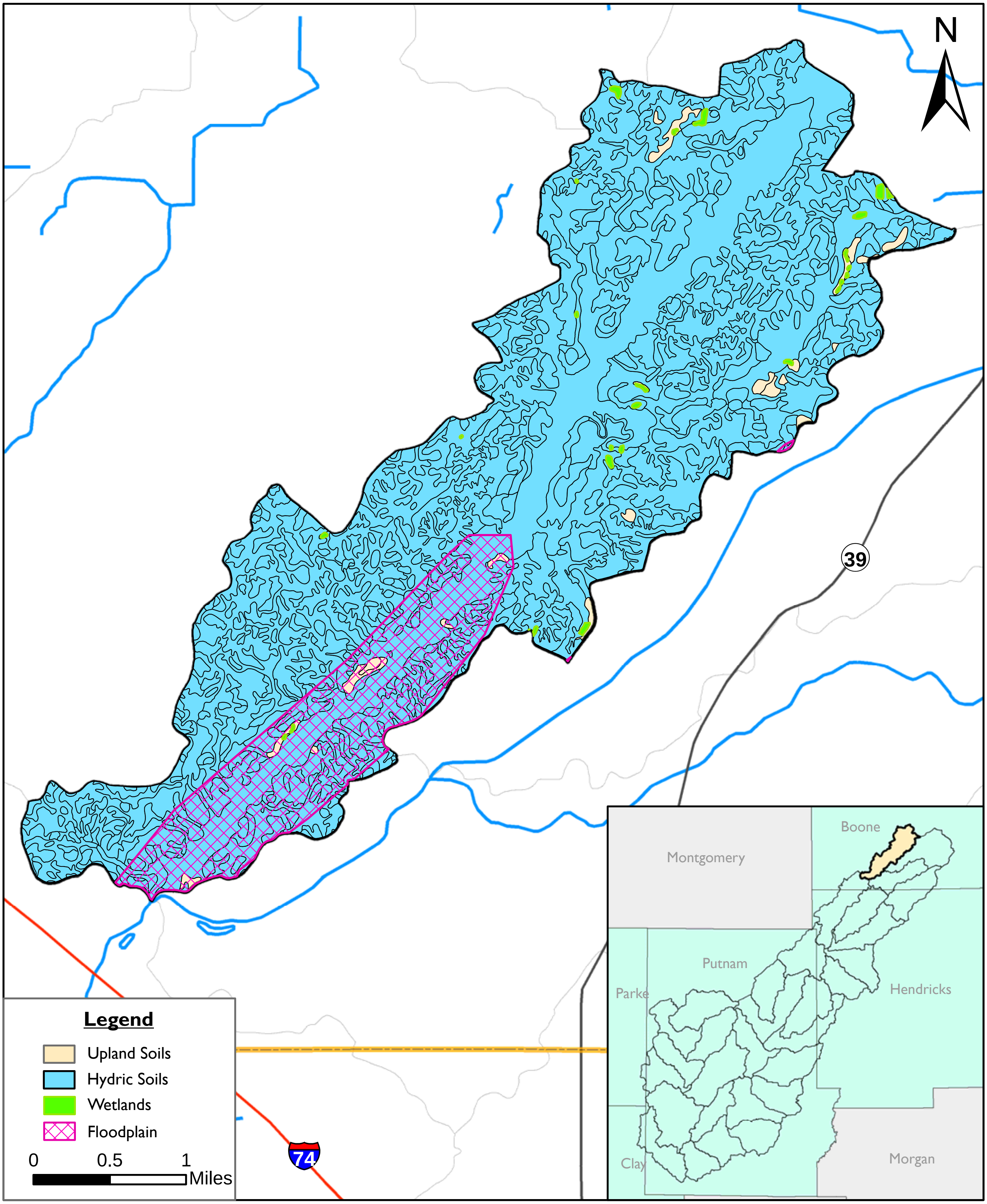


**Figure F19 - Soils, Floodplains, and Wetlands**
**CC - West Fork Big Walnut Creek - Headwaters**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

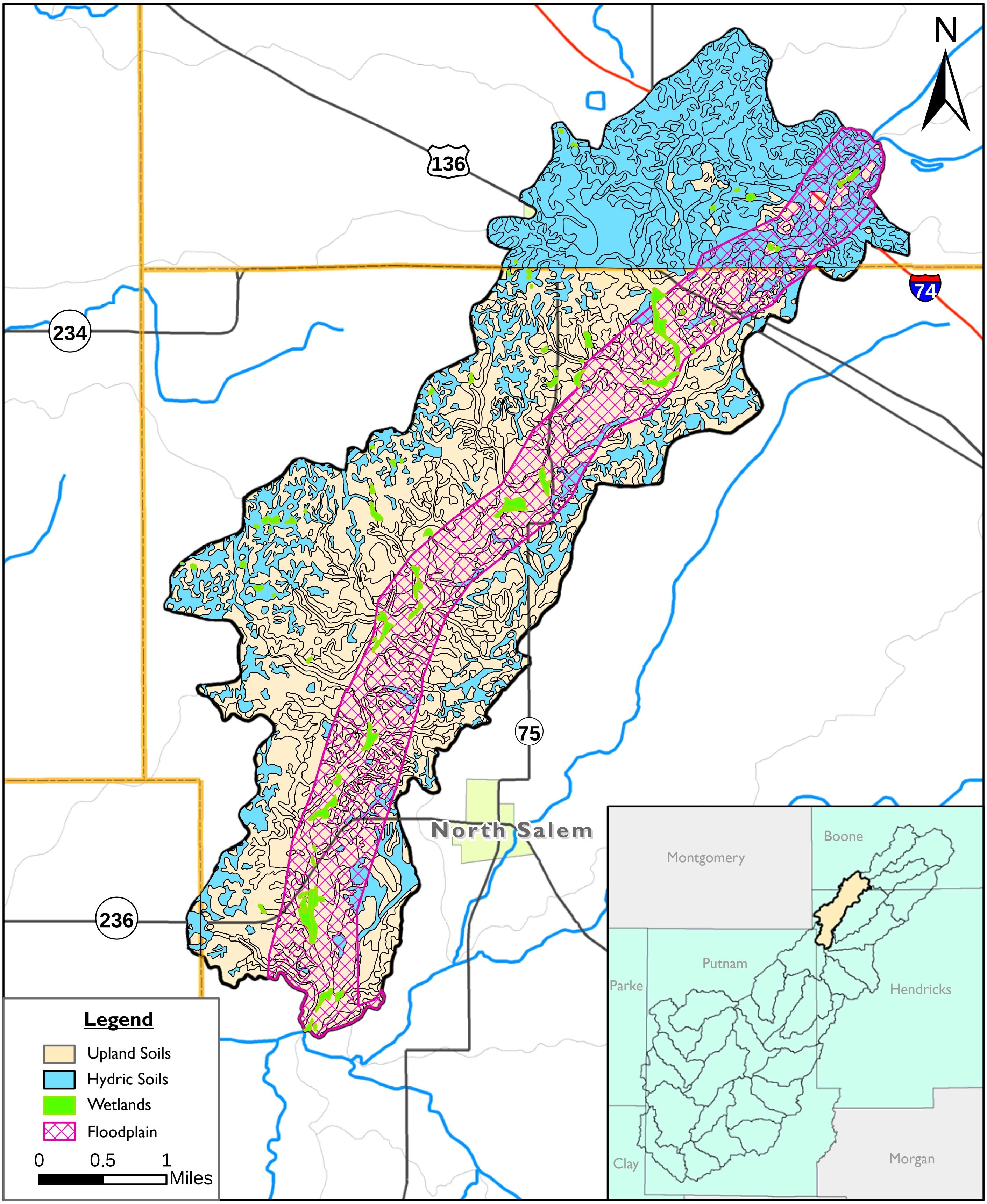


**Figure F20 - Soils, Floodplains, and Wetlands**
**DD - West Fork Big Walnut Creek - Lower**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

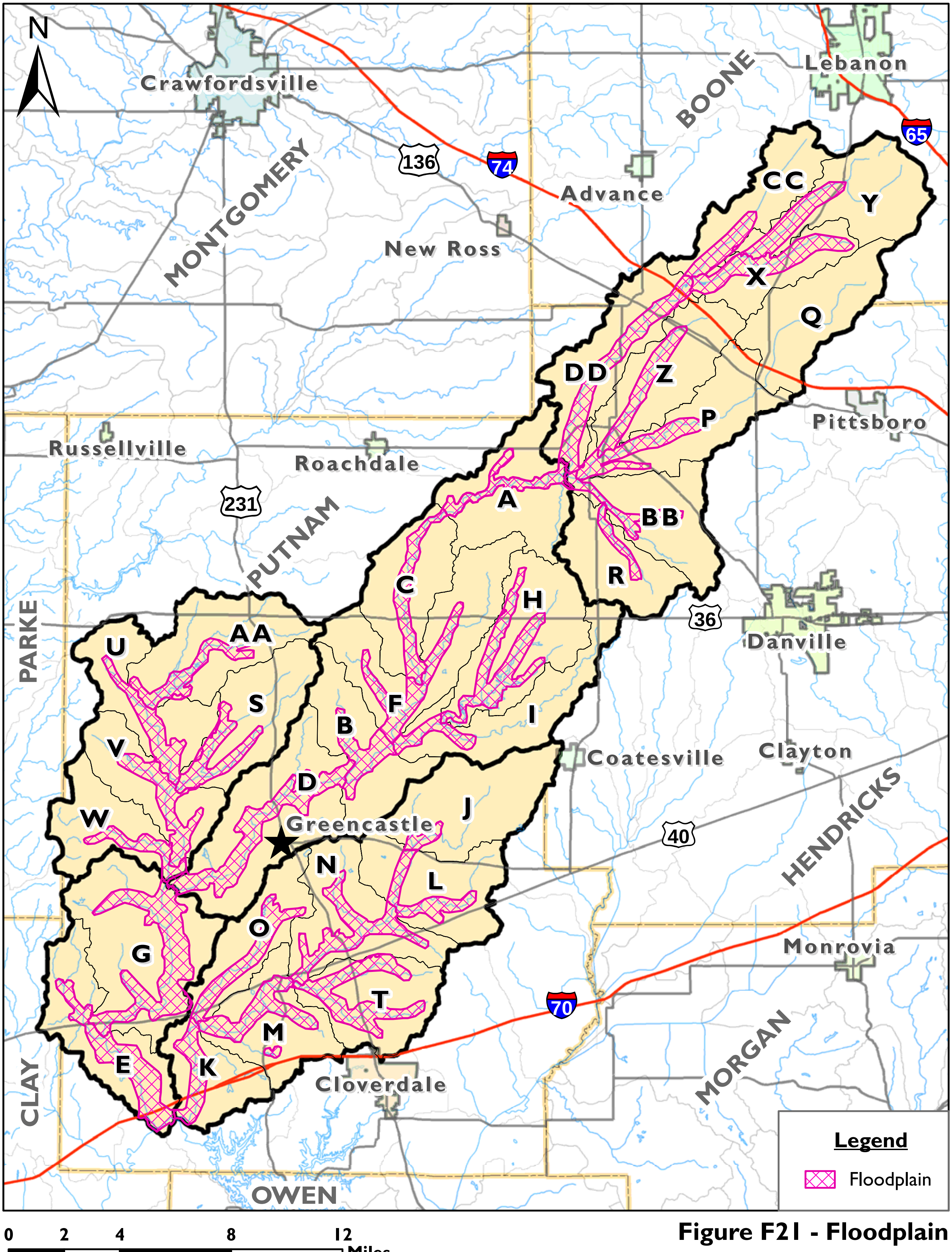


**Figure F21 - Floodplain**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

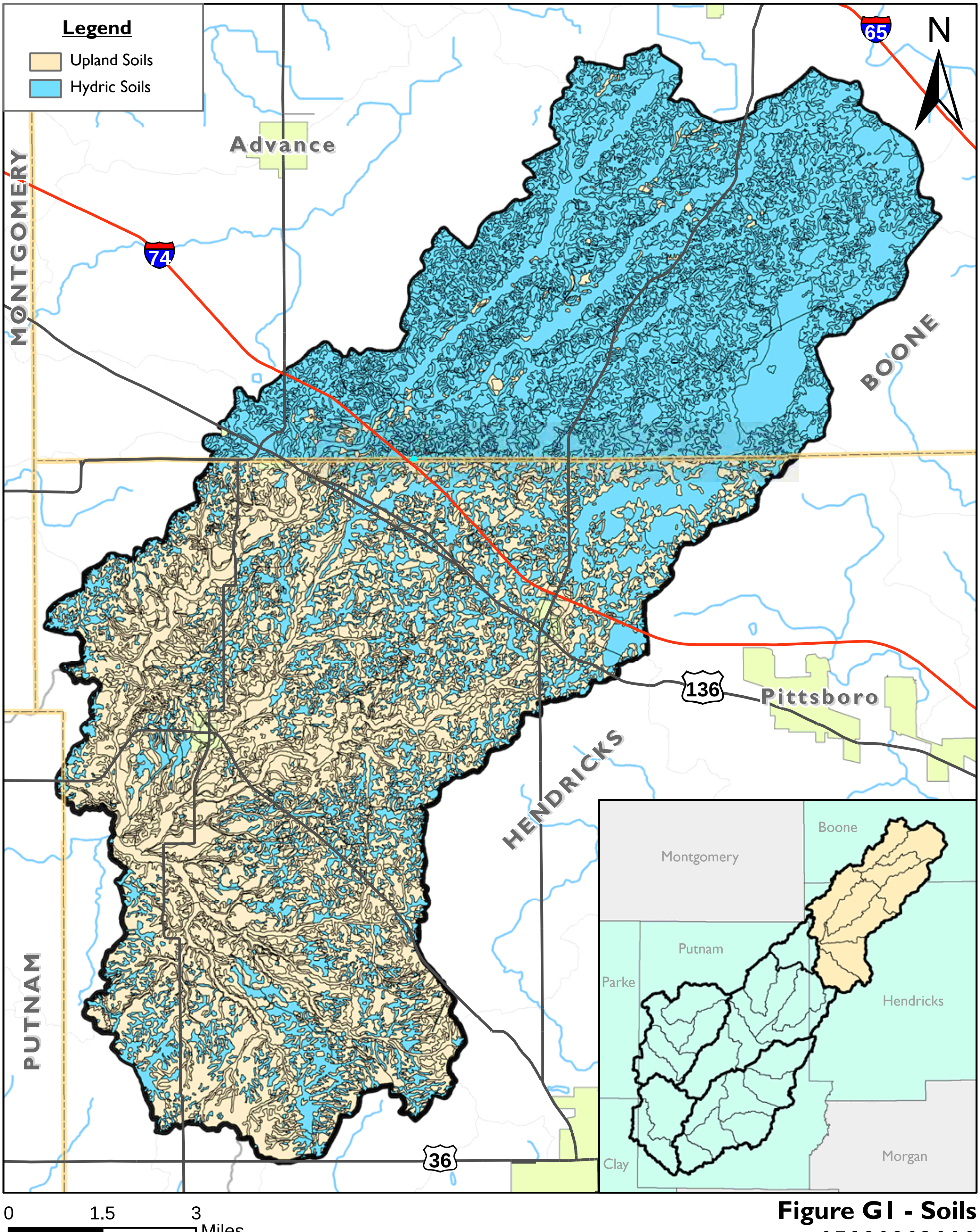


**Figure G1 - Soils**
**05120203010**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

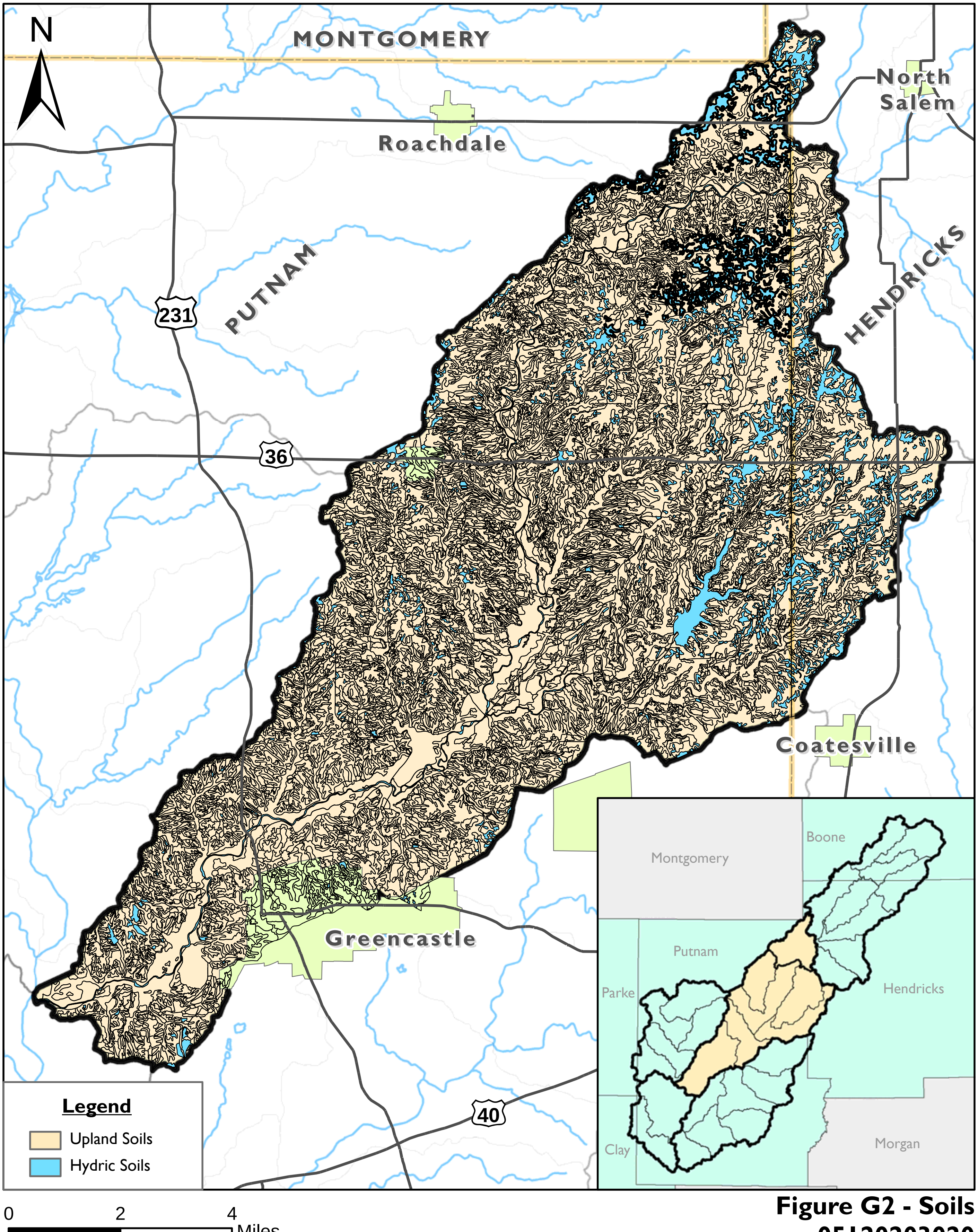


**Figure G2 - Soils**
**05120203020**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

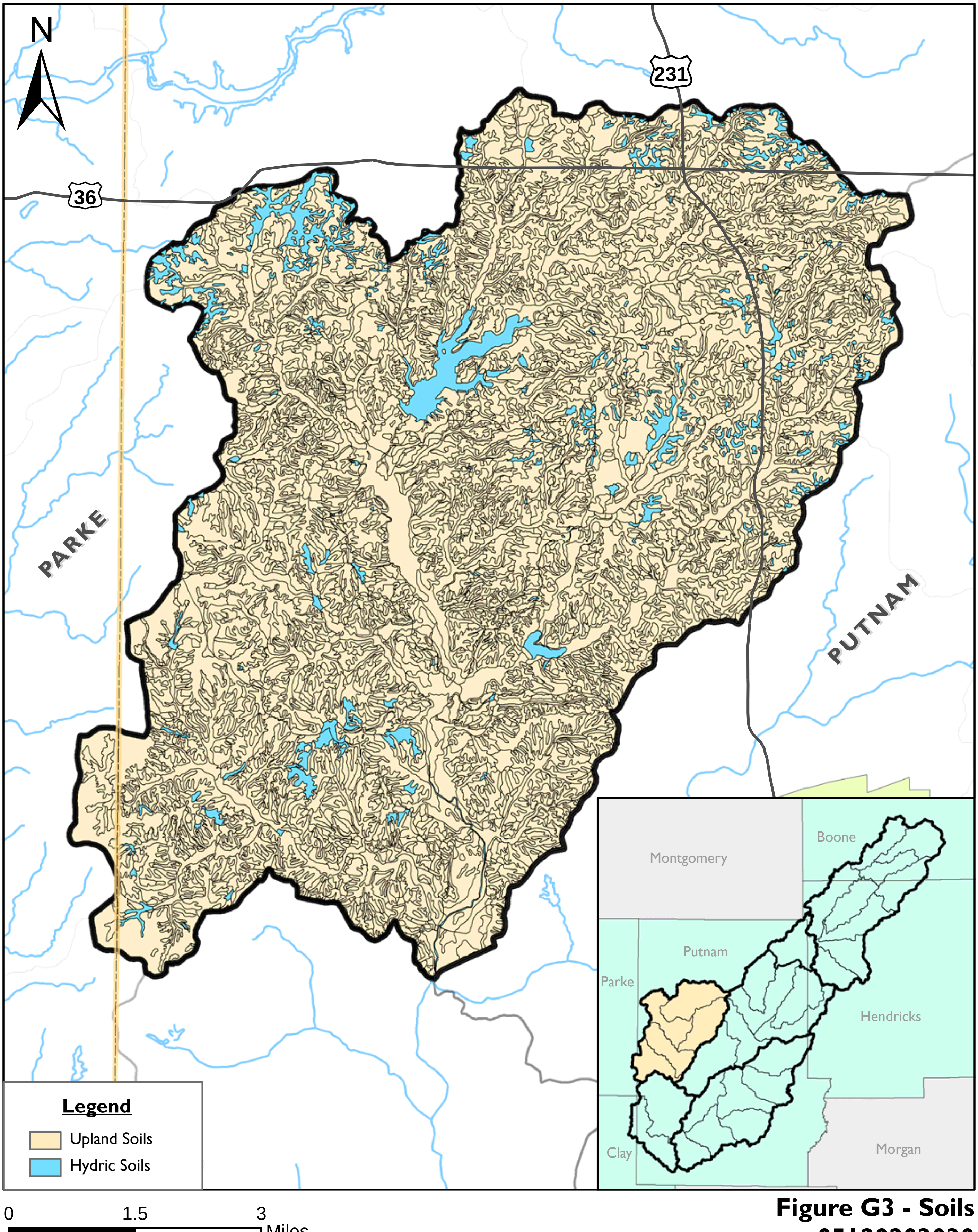


**Figure G3 - Soils**
**05120203030**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

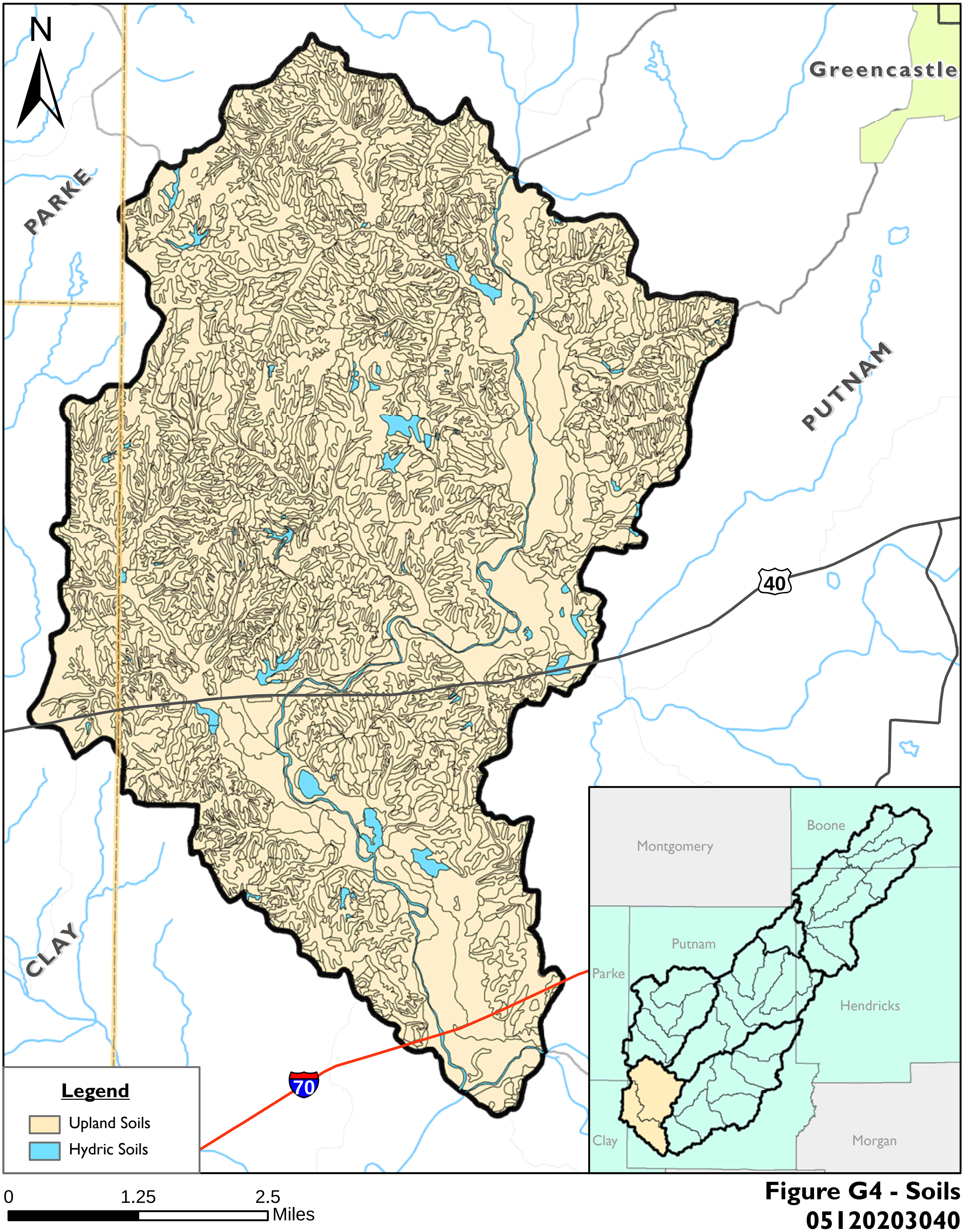


**Figure G4 - Soils**
**05120203040**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

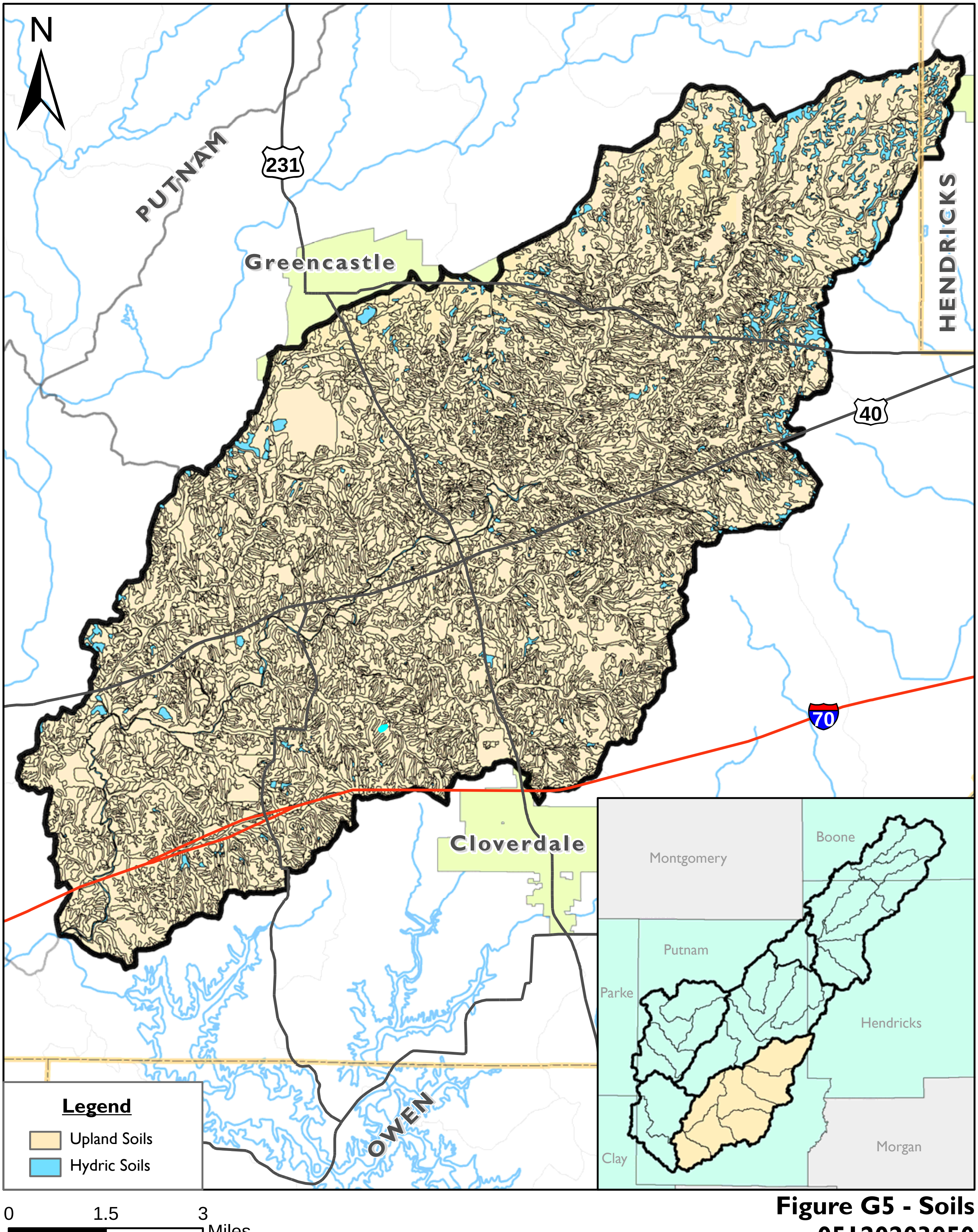


**Figure G5 - Soils**
**05120203050**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

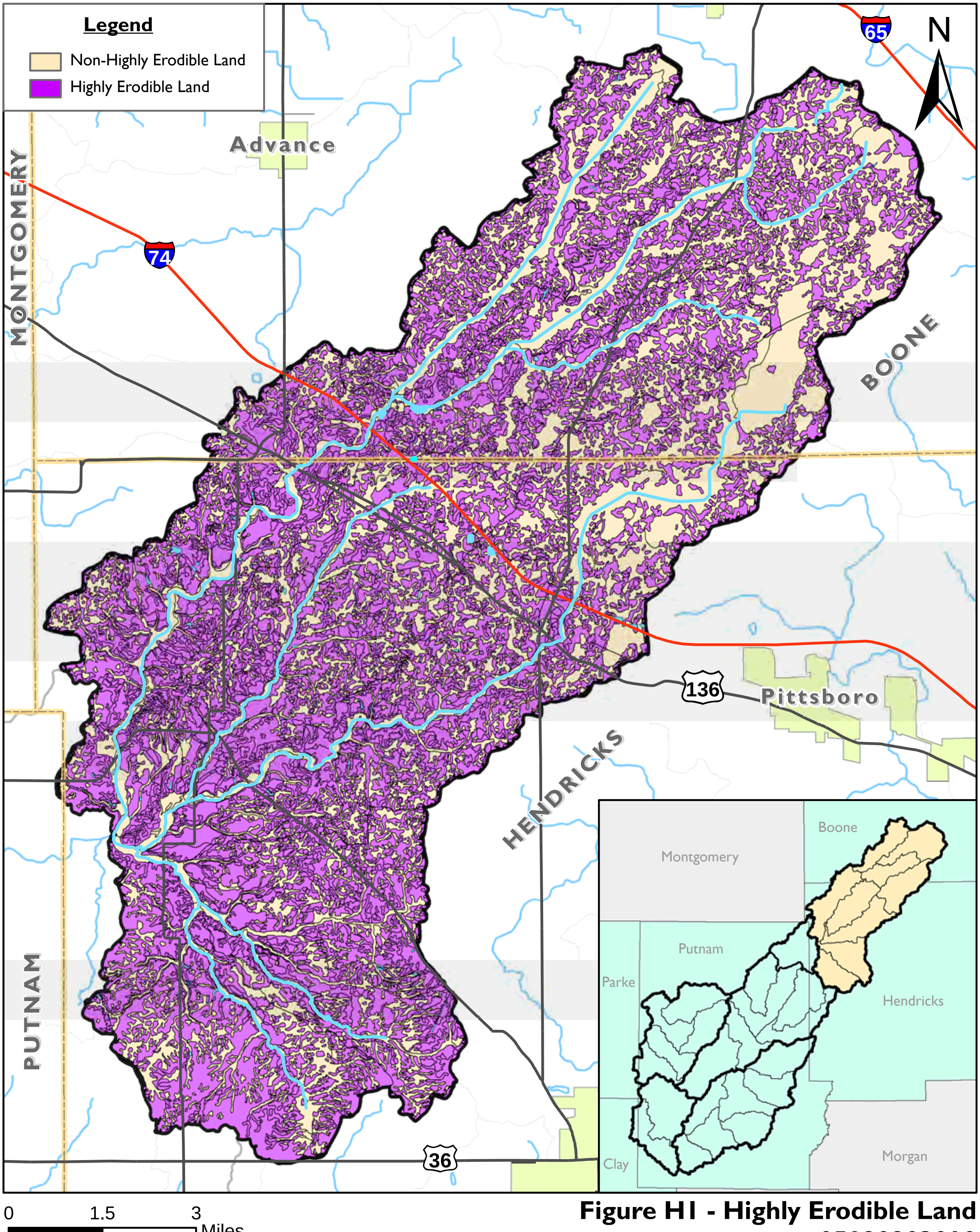


**Figure H1 - Highly Erodible Land**
**05120203010**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

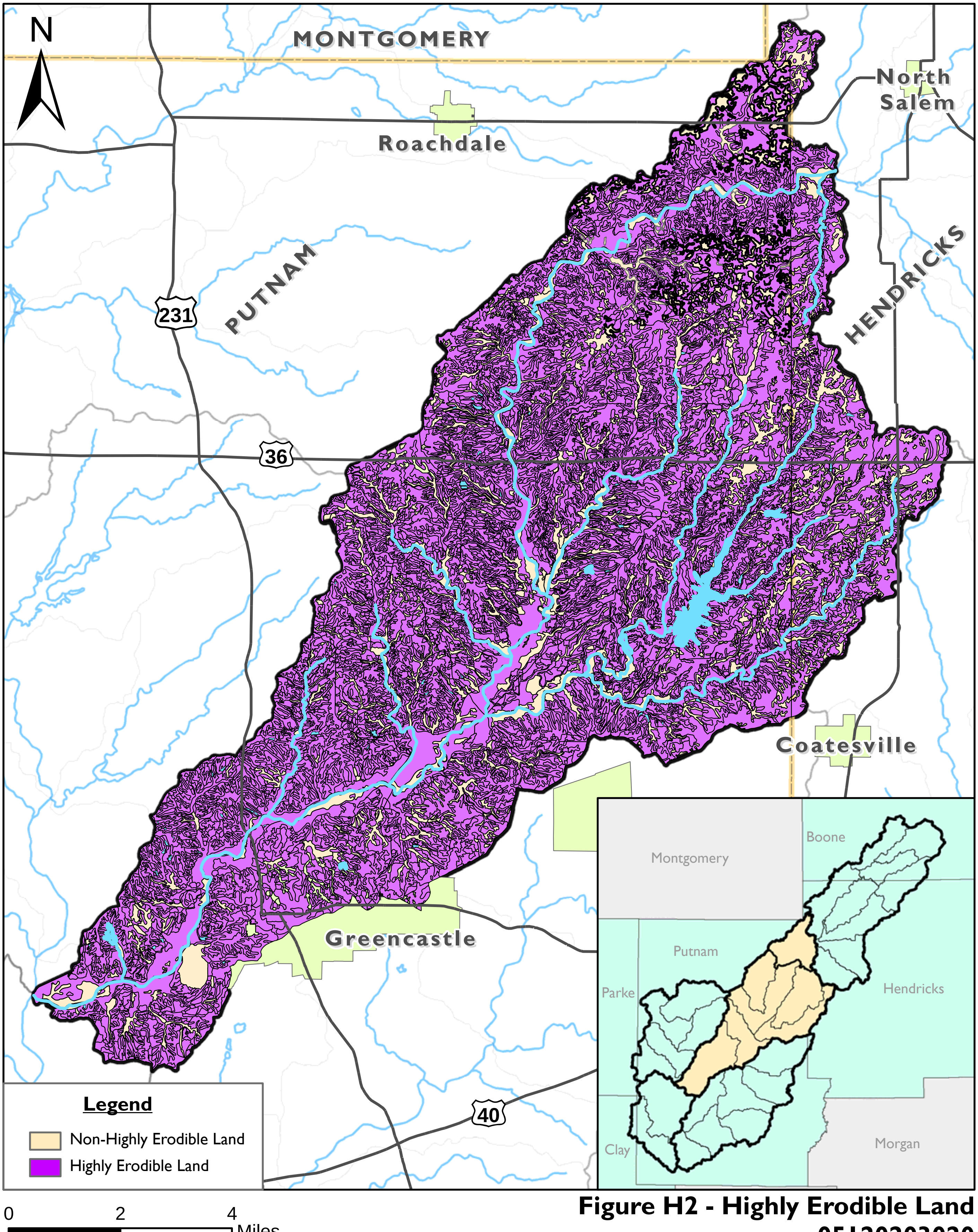


**Figure H2 - Highly Erodible Land**
**05120203020**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

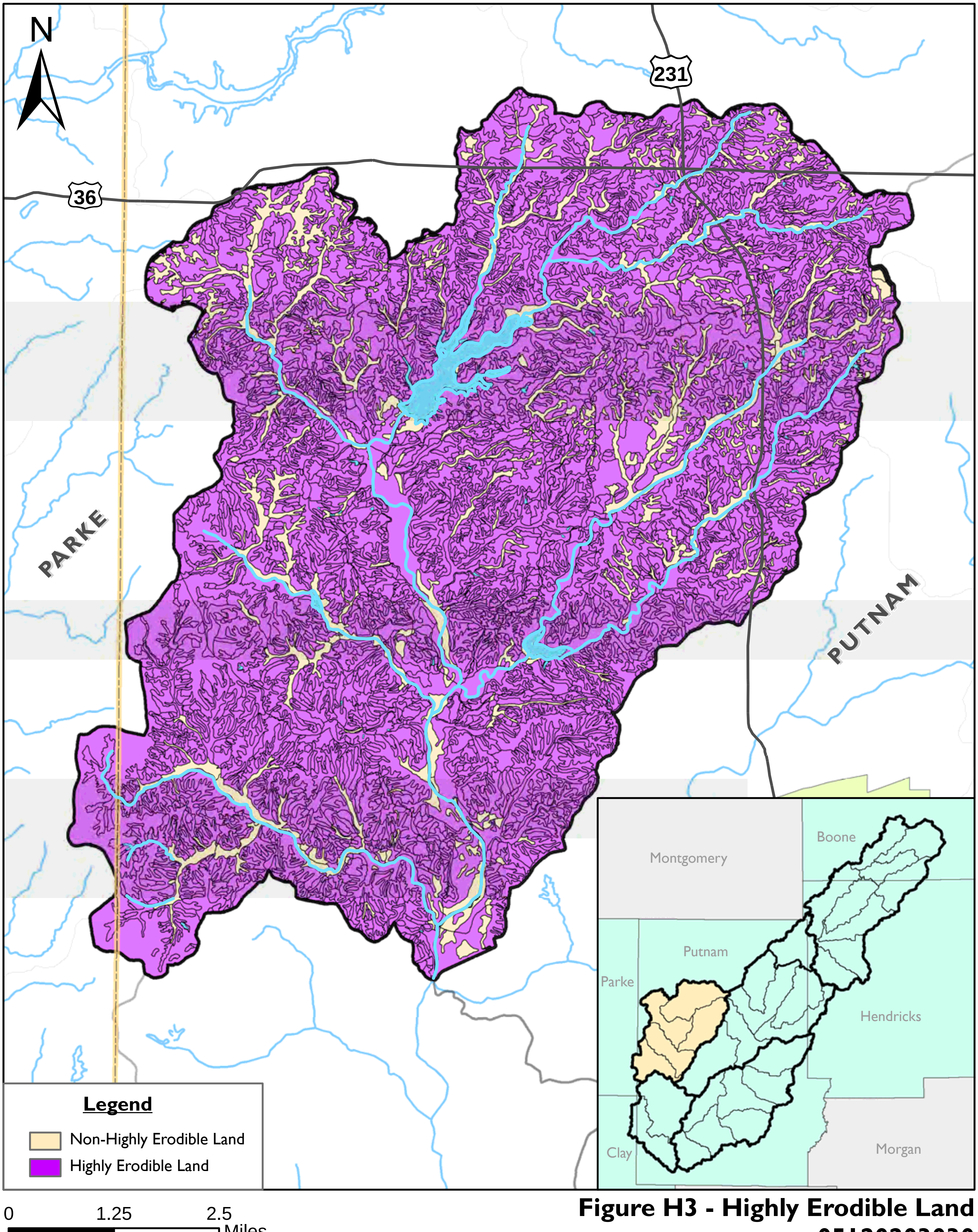


**Figure H3 - Highly Erodible Land**
**05120203030**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

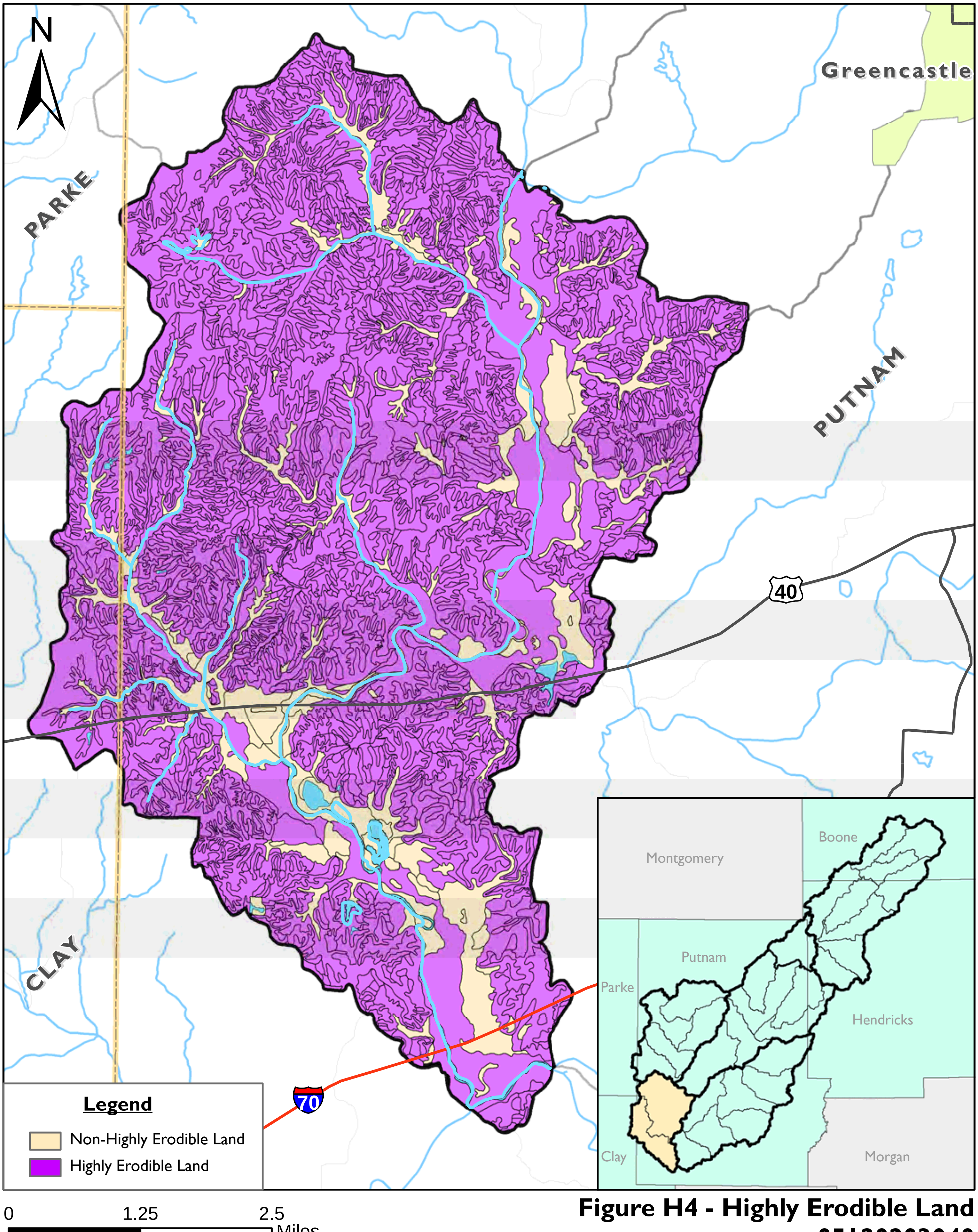


**Figure H4 - Highly Erodible Land**
**05120203040**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

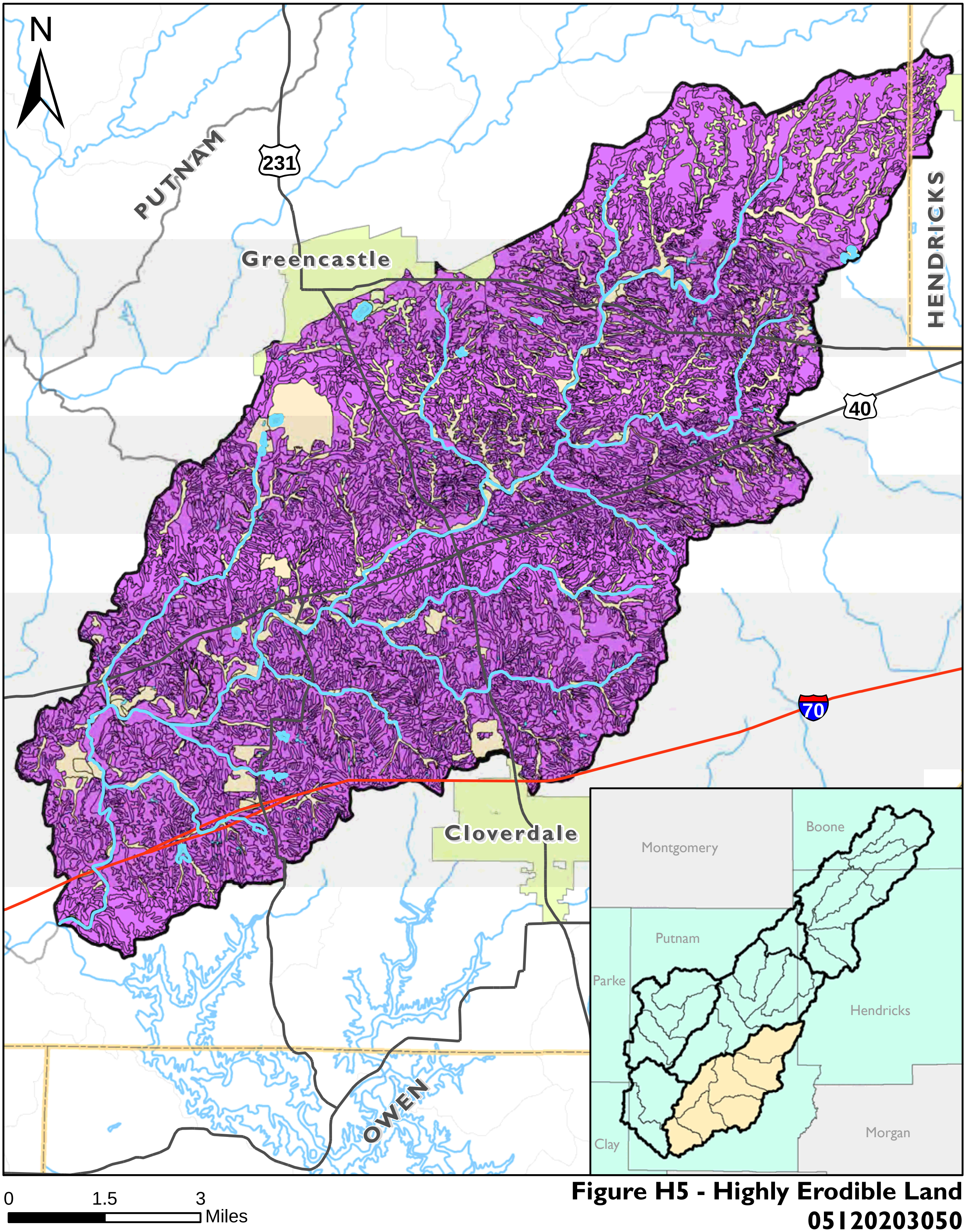


**Figure H5 - Highly Erodible Land**
**05120203050**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

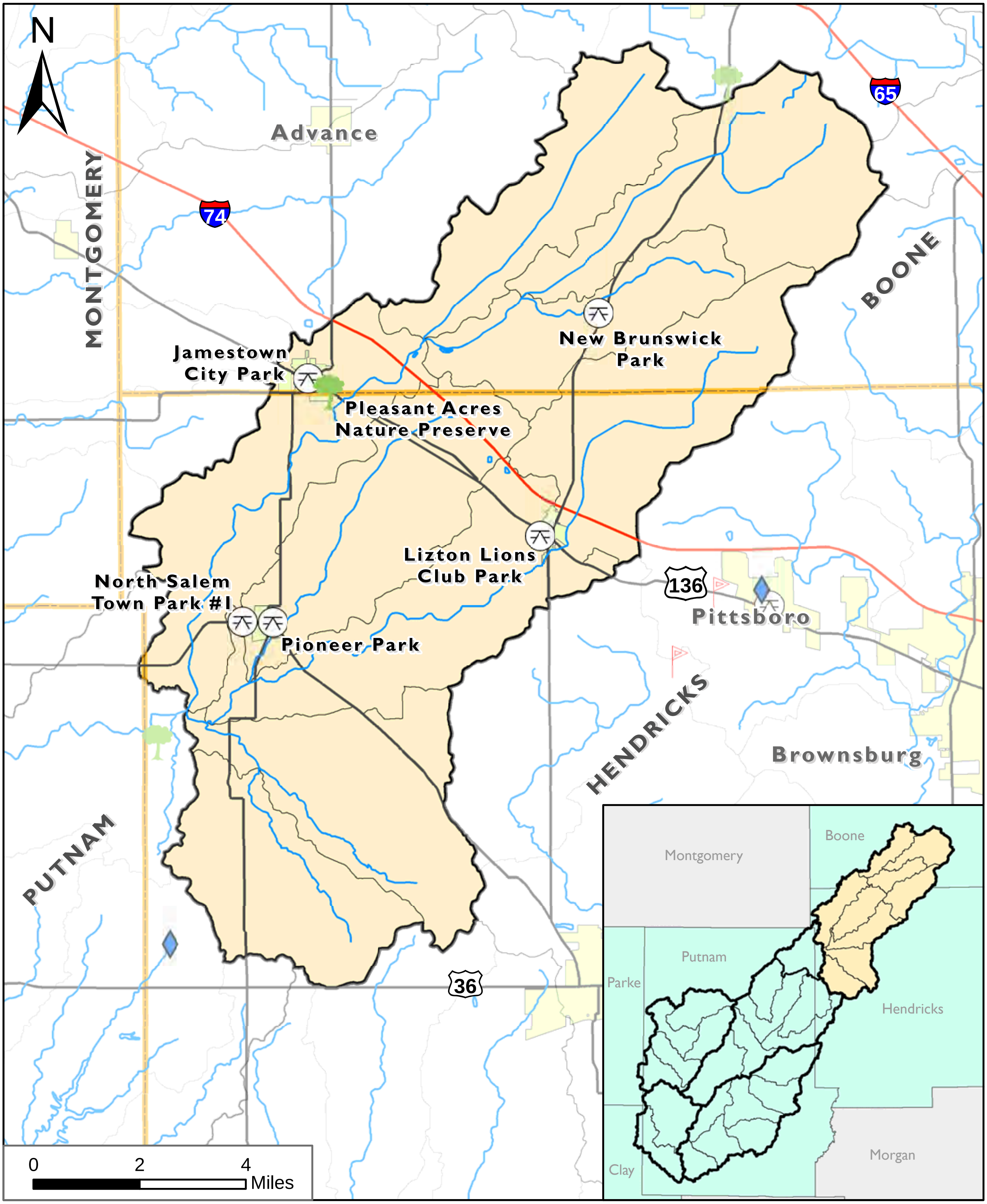


**Figure J1 - Natural and Recreational Areas**
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**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

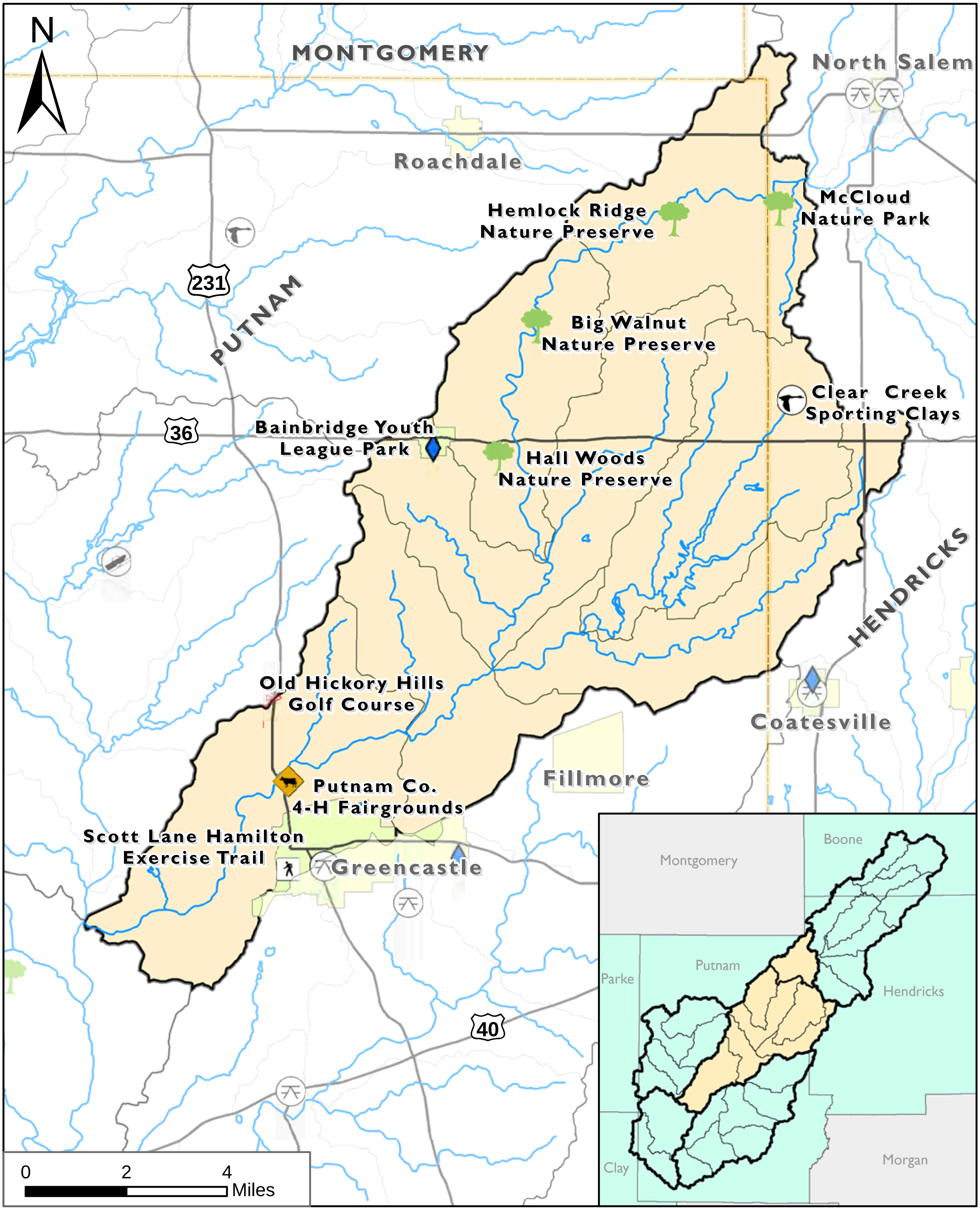



**Figure J2 - Natural and Recreational Areas**
**05120203020**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

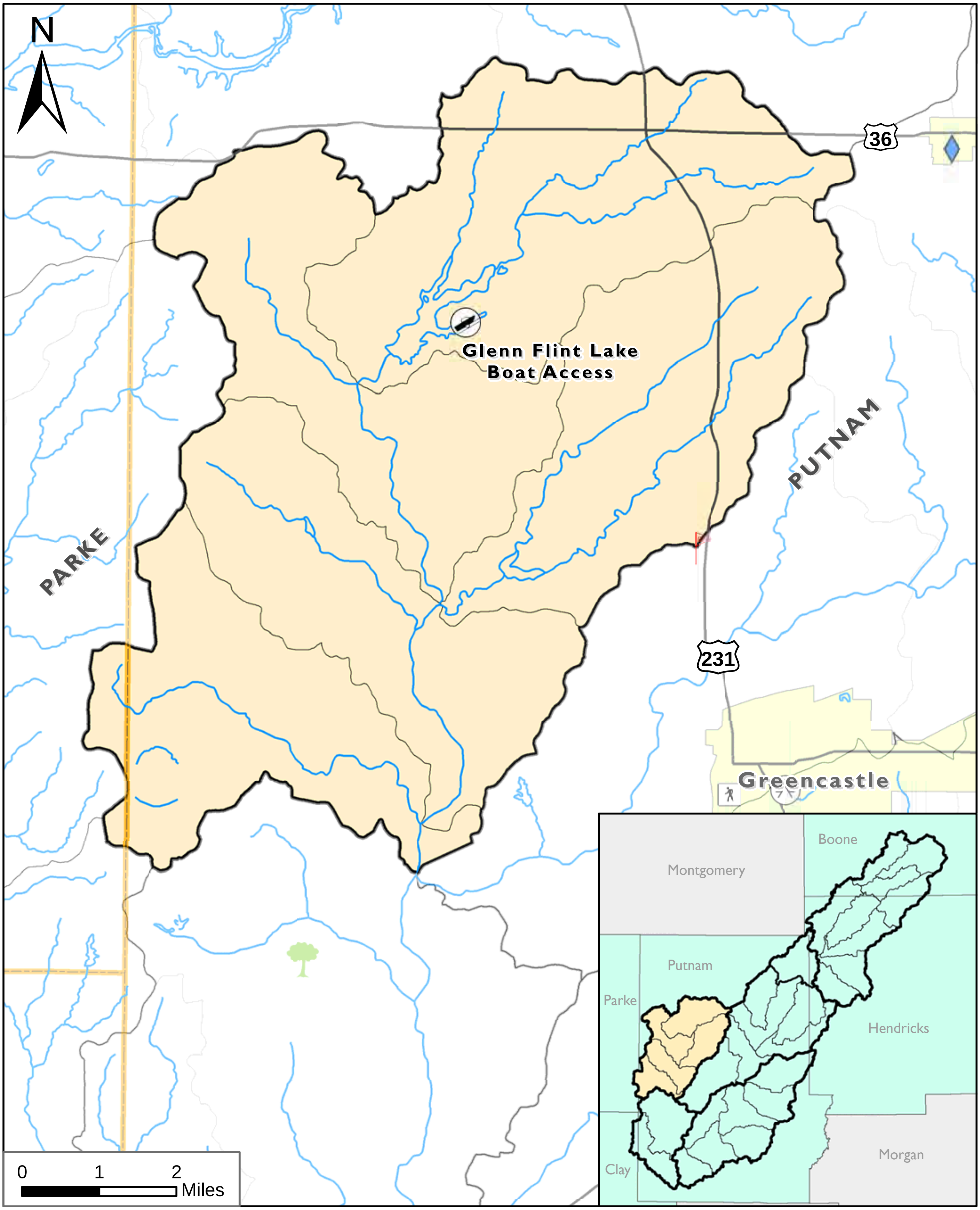



**Figure J3 - Natural and Recreational Areas**
**05120203030**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

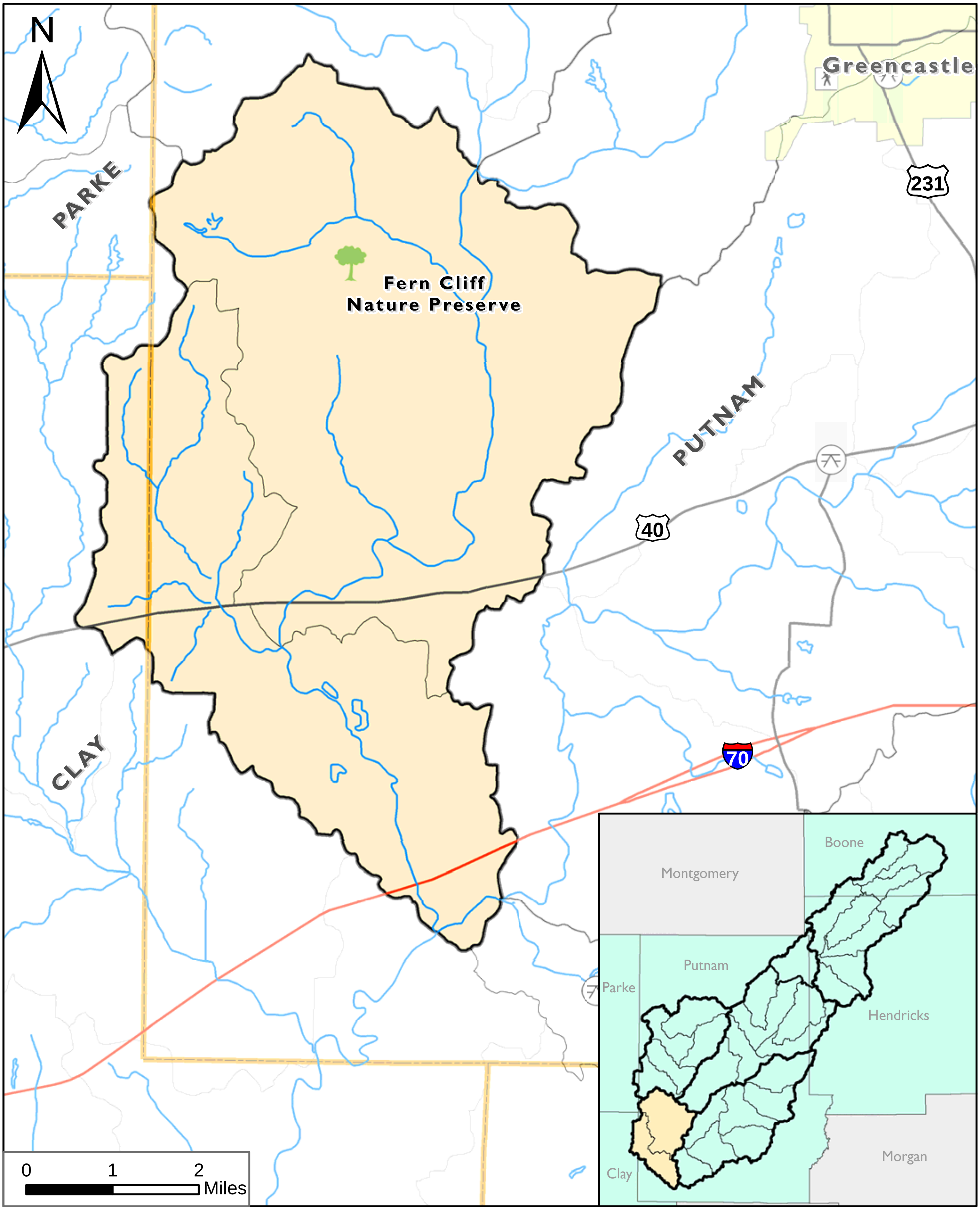



**Figure J4 - Natural and Recreational Areas**
**05120203040**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

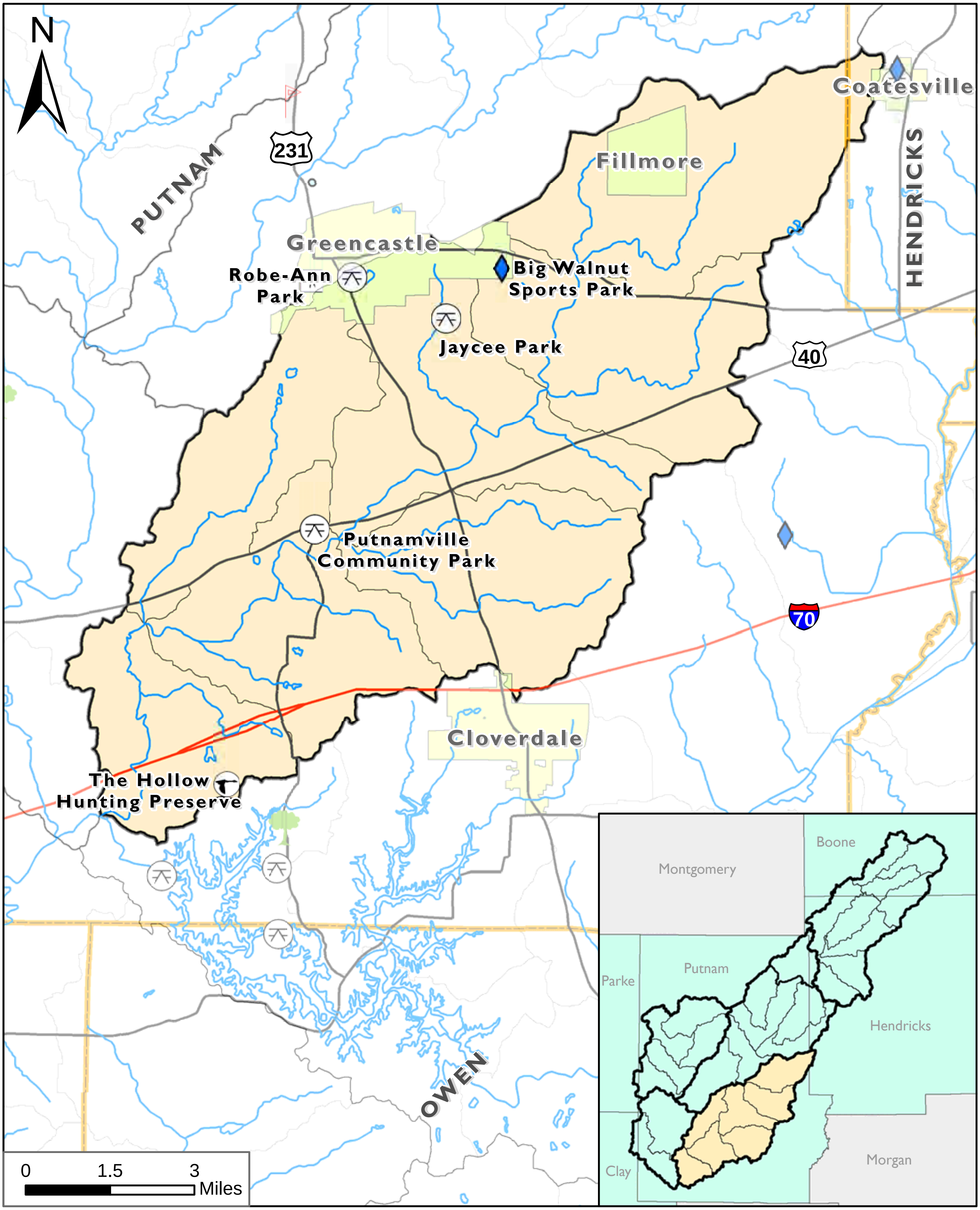



**Figure J5 - Natural and Recreational Areas**
**05120203050**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

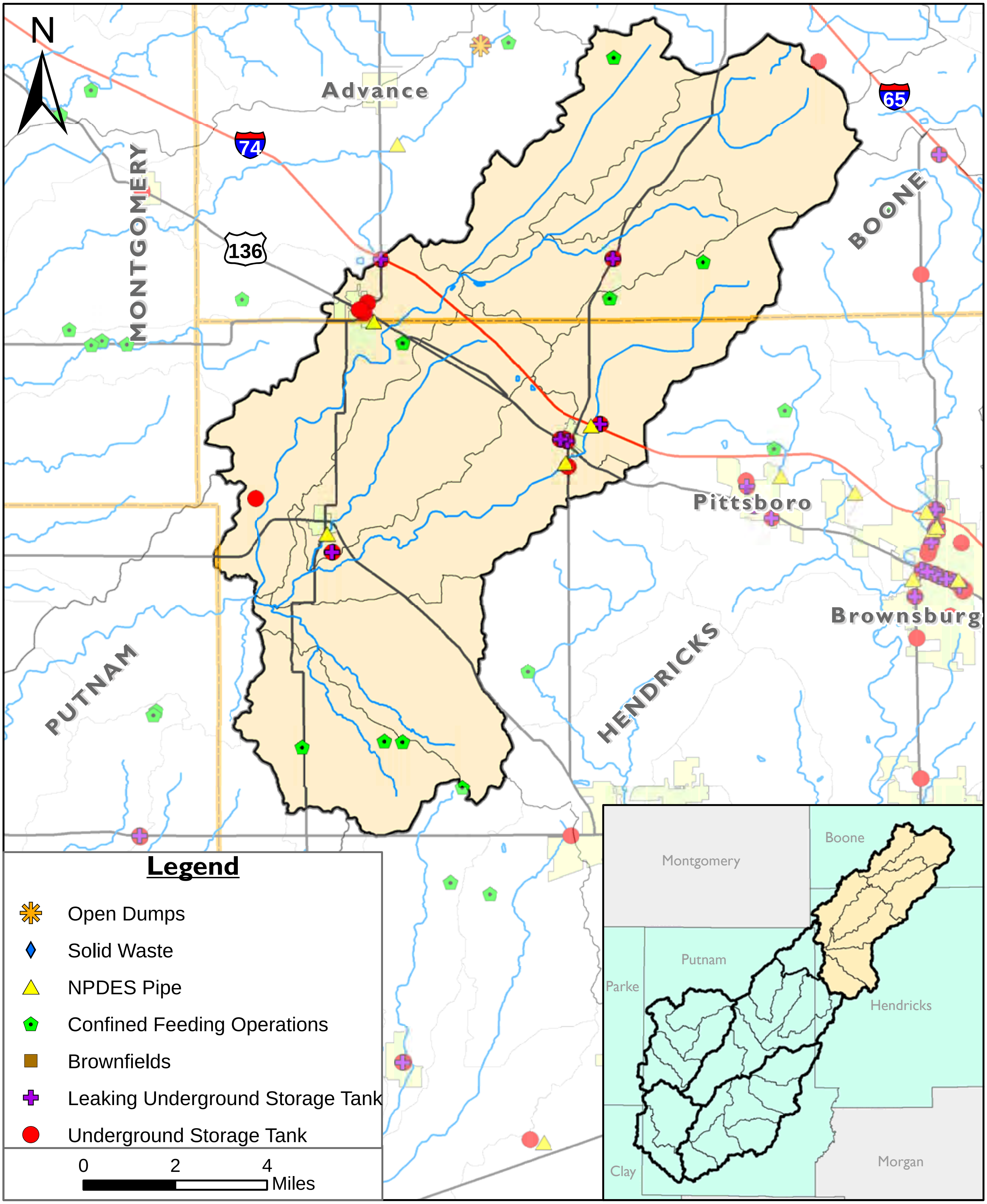



**Figure P1 - Environmental Issues**
**05120203010**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

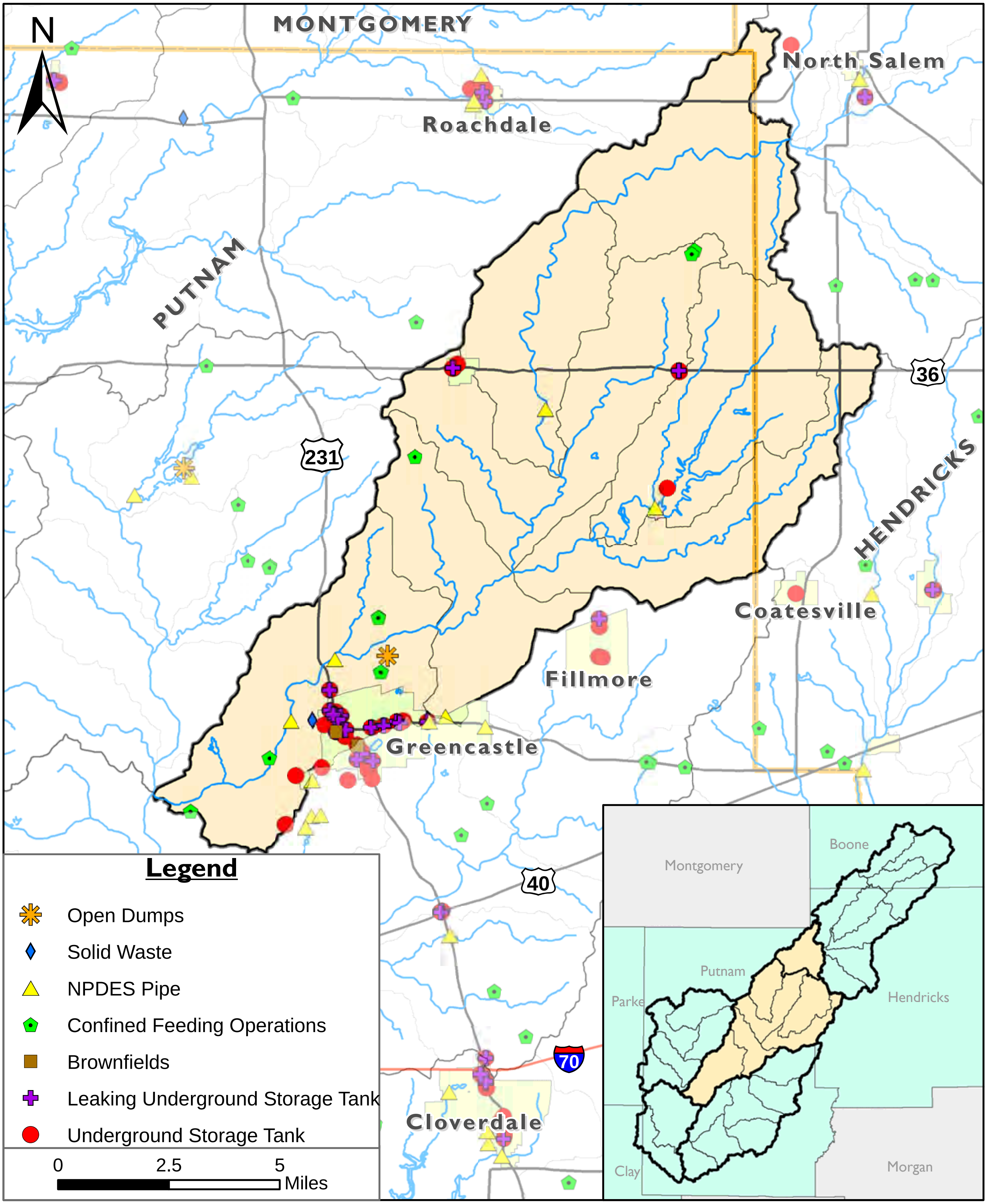



**Figure P2 - Environmental Issues**
**05120203020**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

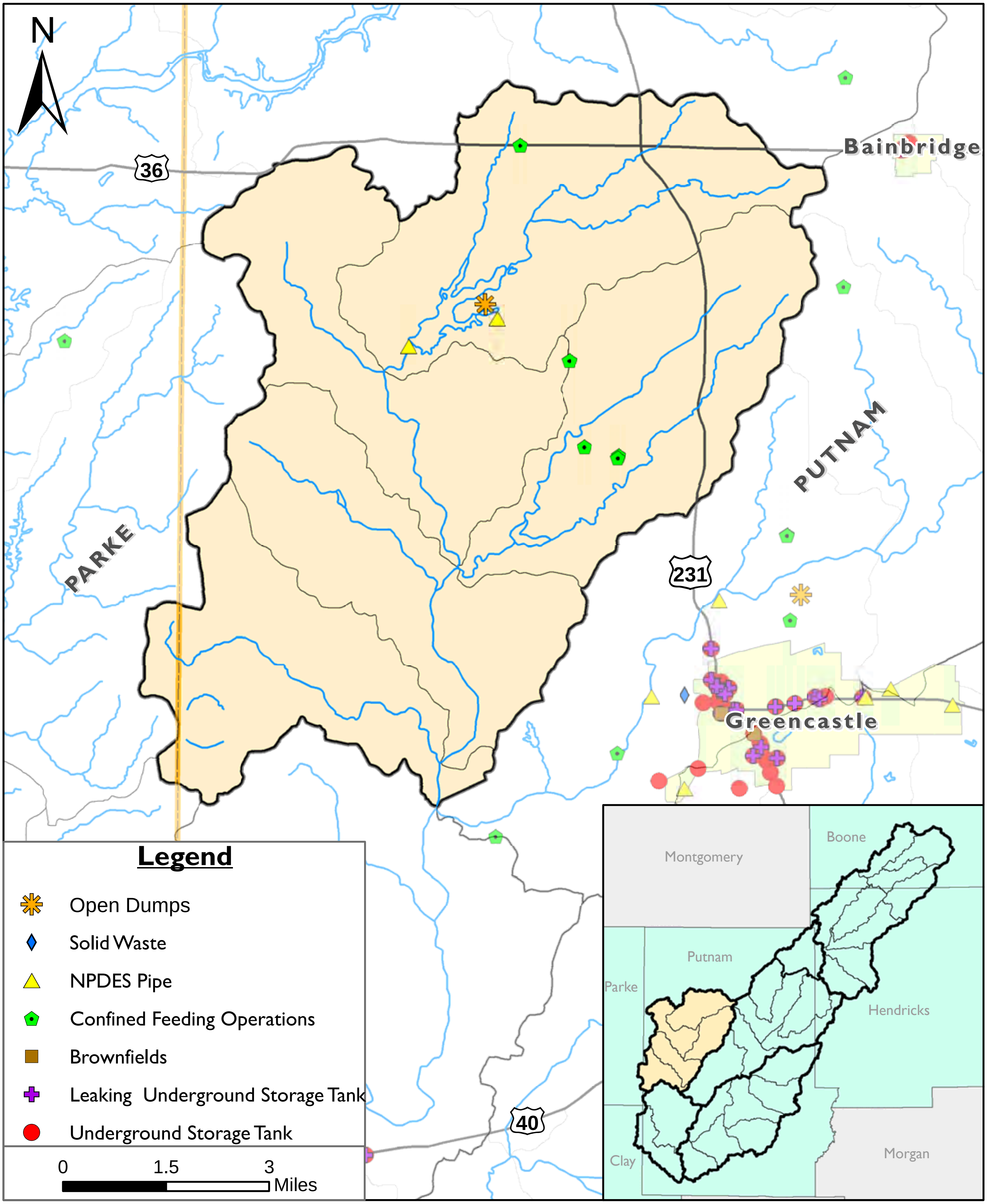



**Figure P3 - Environmental Issues**
**05120203030**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

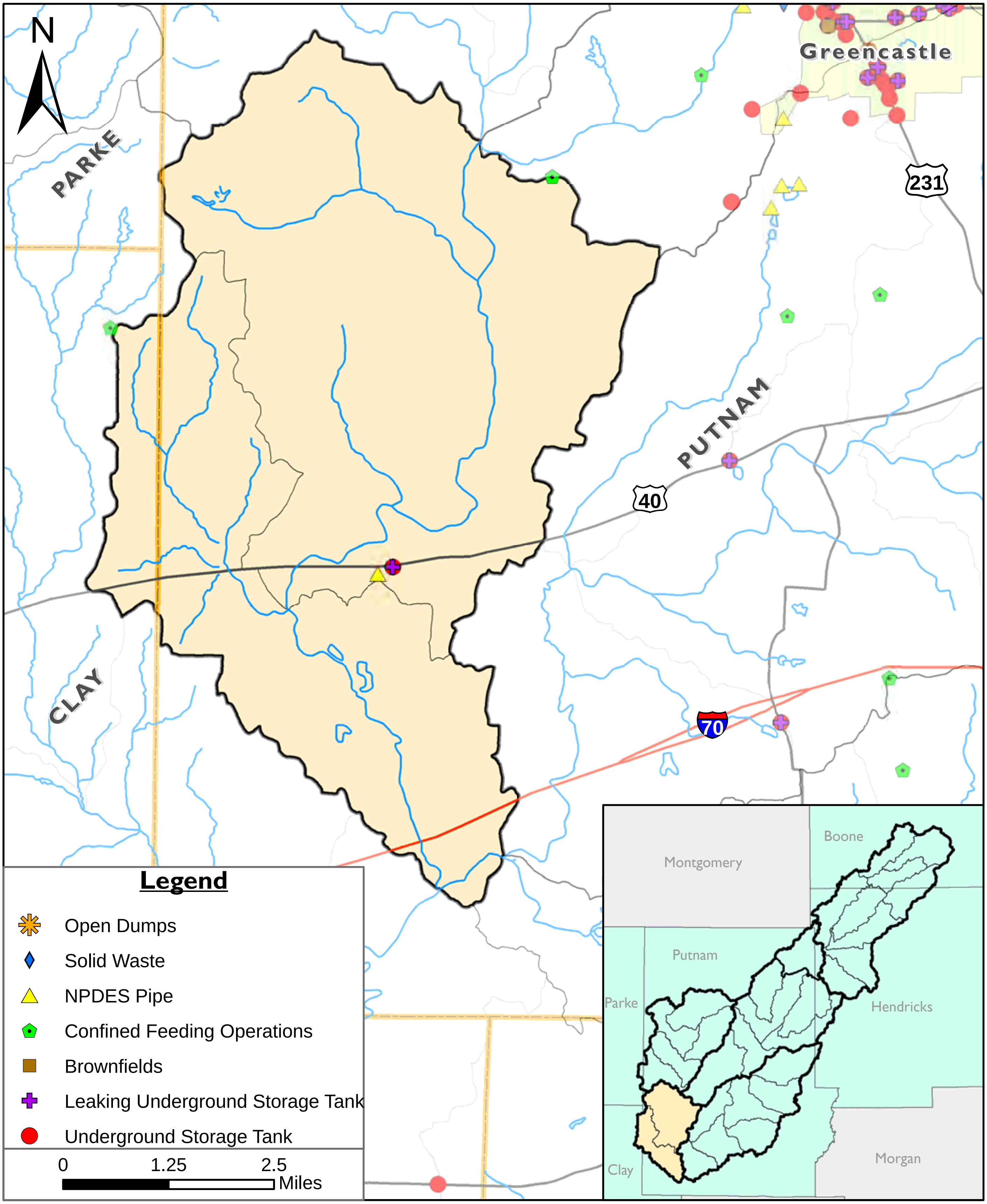



**Figure P4 - Environmental Issues**
**05120203040**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

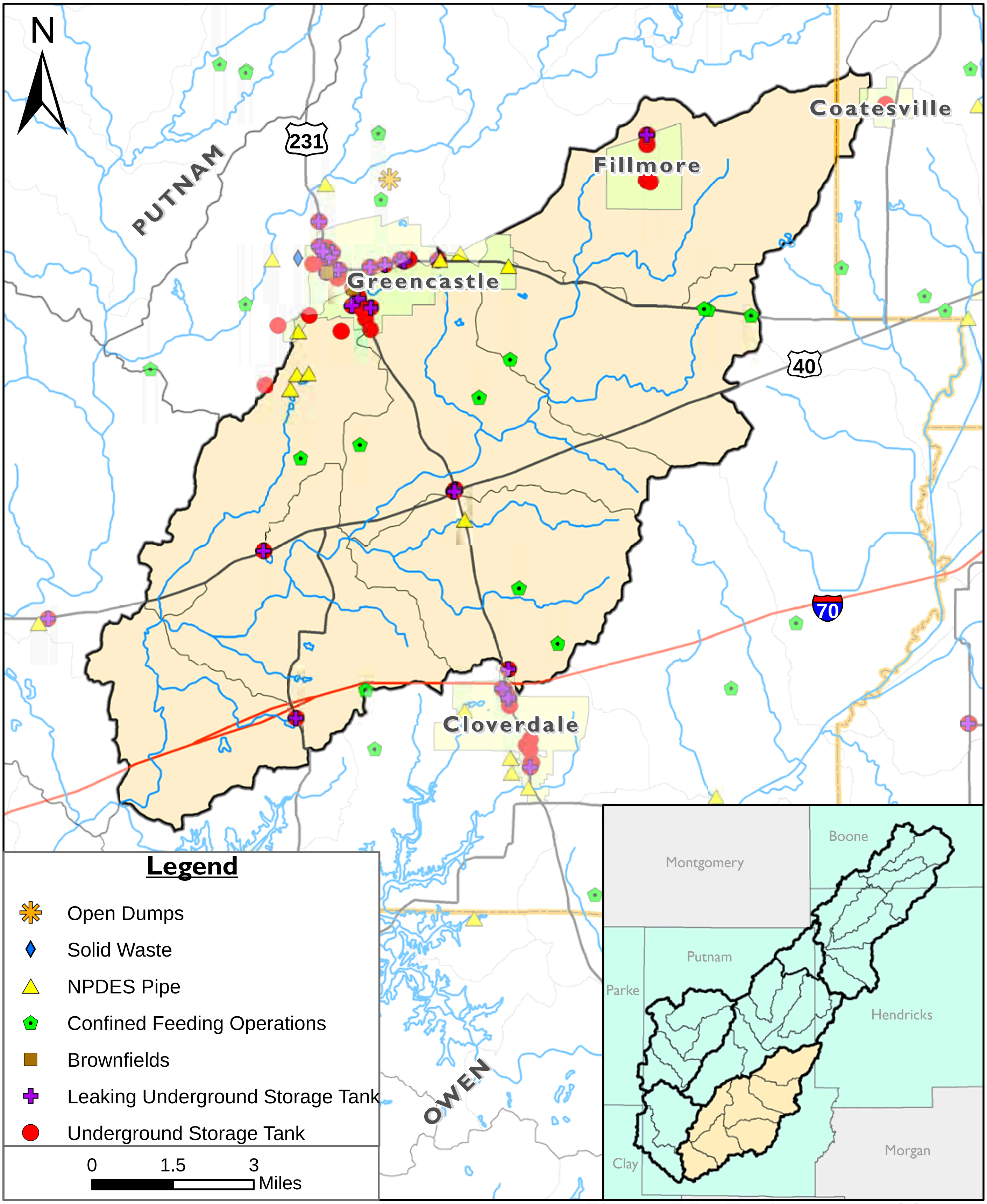



**Figure P5 - Environmental Issues**
**05120203050**
**11-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

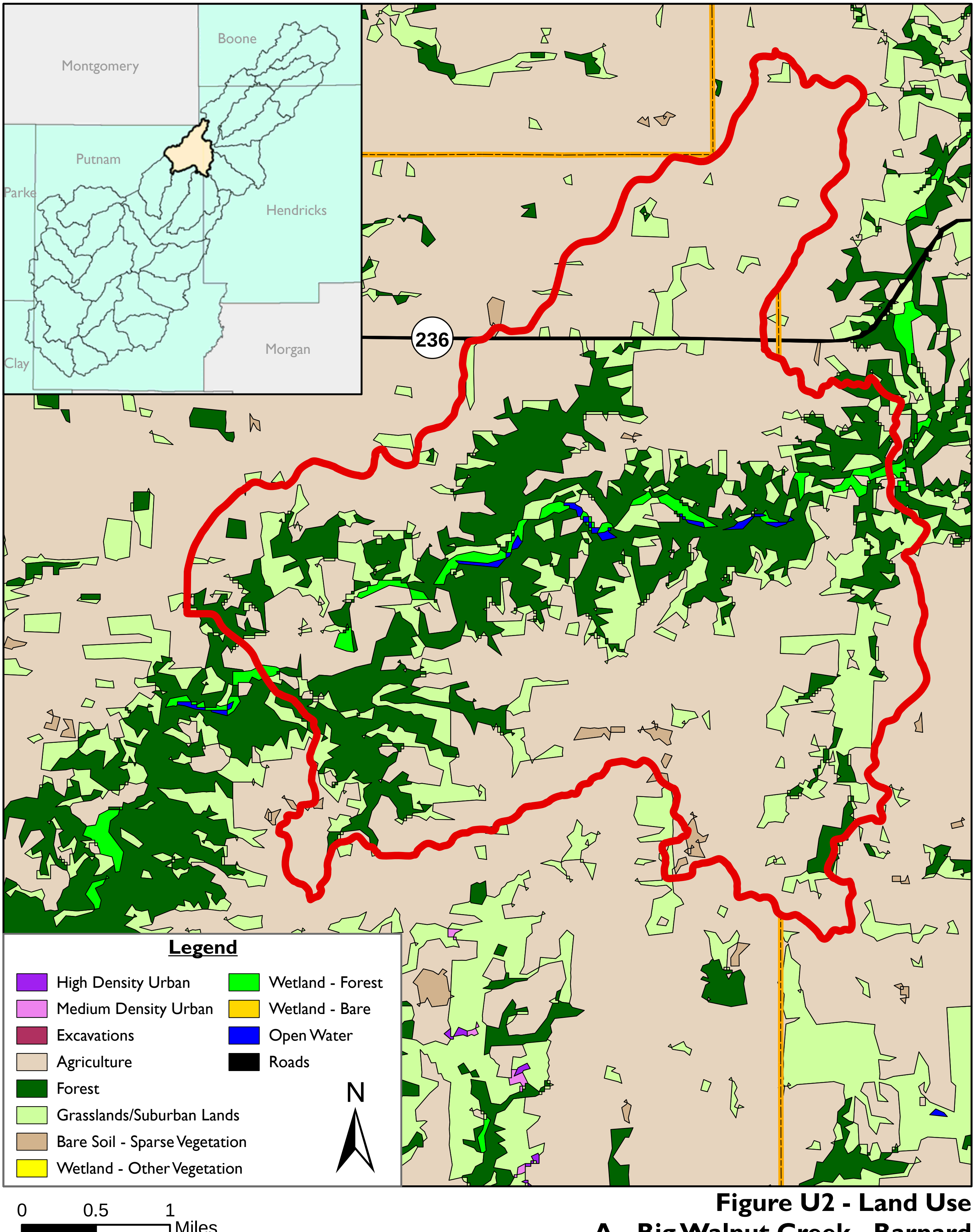



**Figure U2 - Land Use**
**A - Big Walnut Creek - Barnard**
**14-HUC Watershed**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

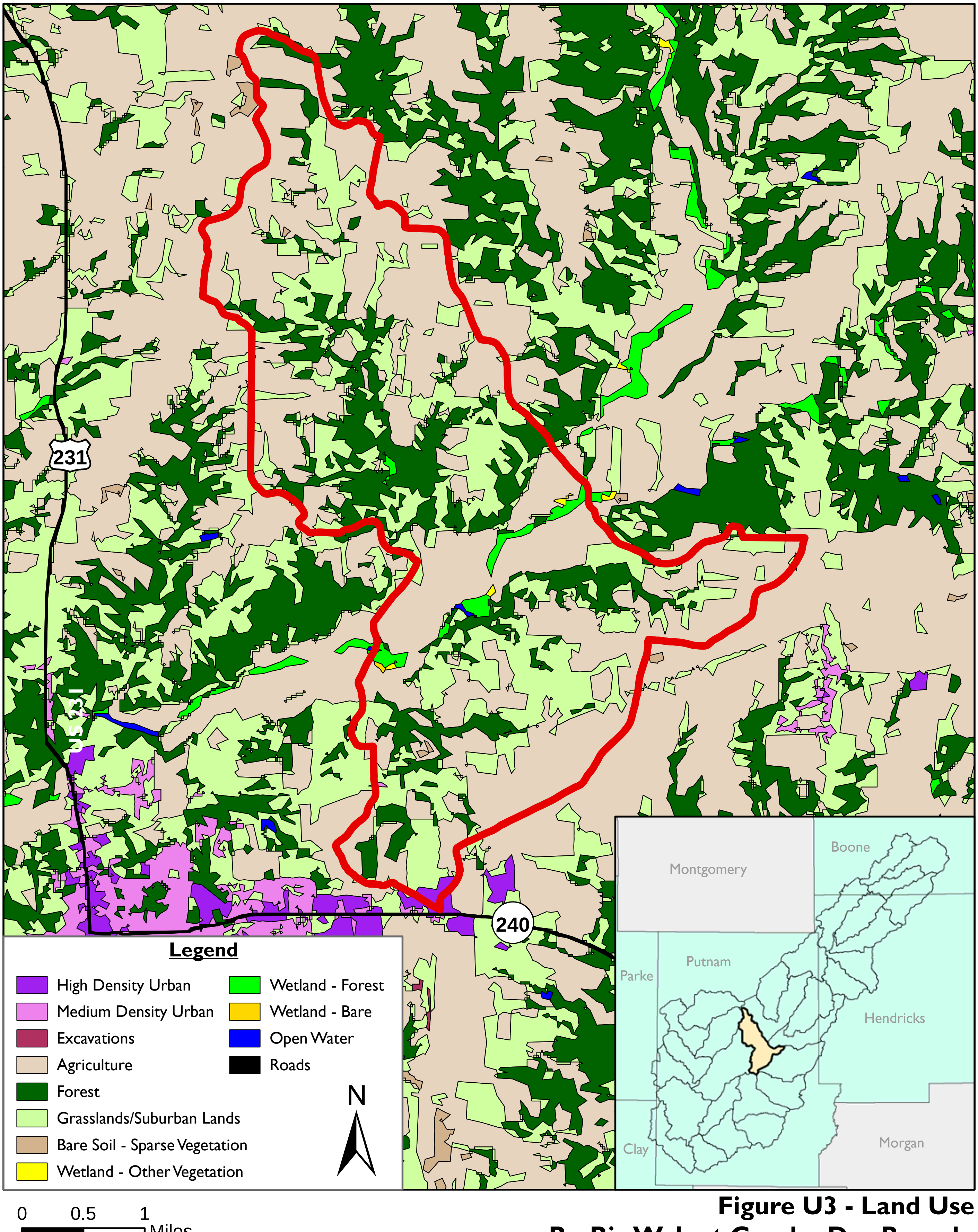



**Figure U3 - Land Use**
**B - Big Walnut Creek - Dry Branch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

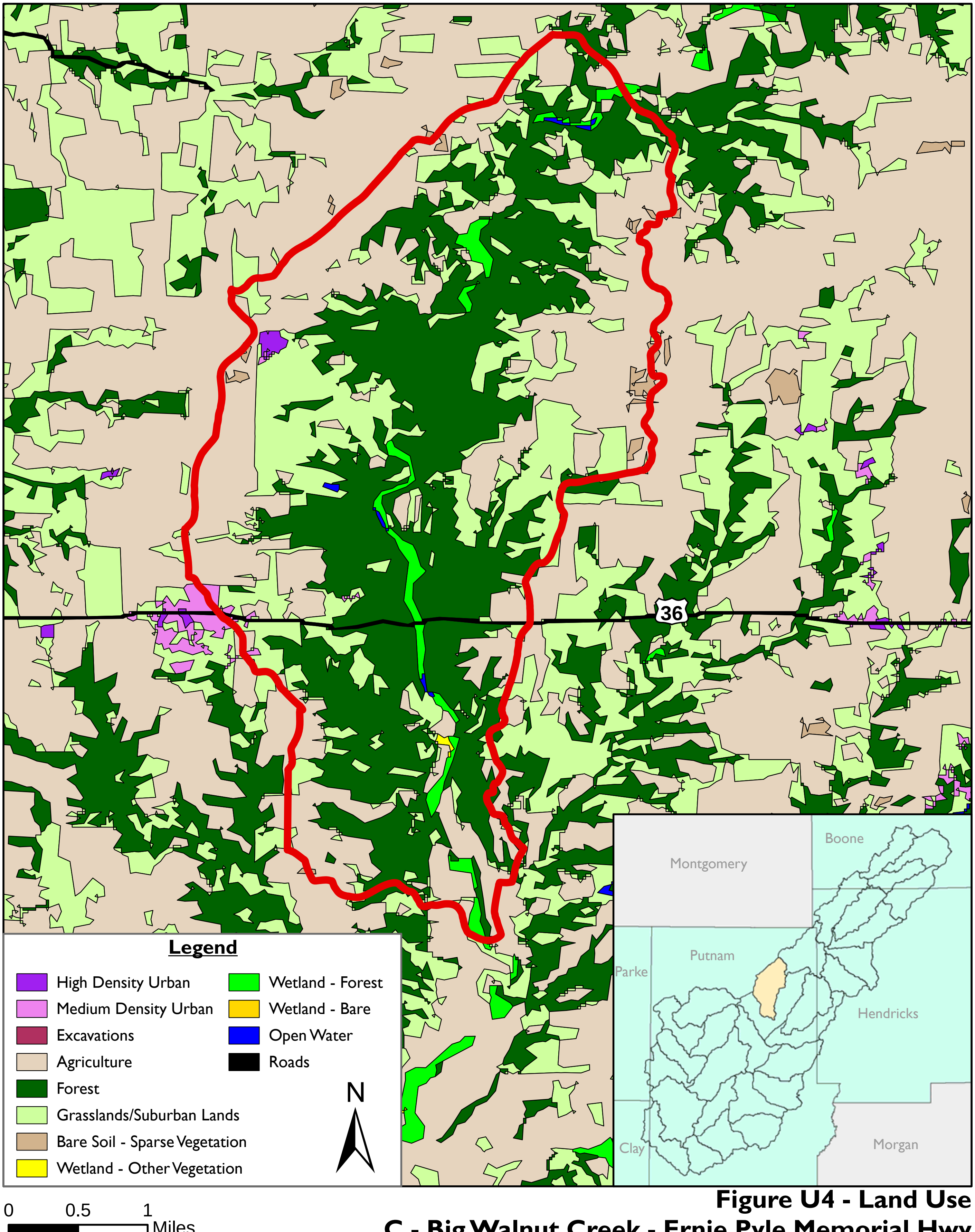



**Figure U4 - Land Use**

**C - Big Walnut Creek - Ernie Pyle Memorial Hwy**

**14-HUC Watershed**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

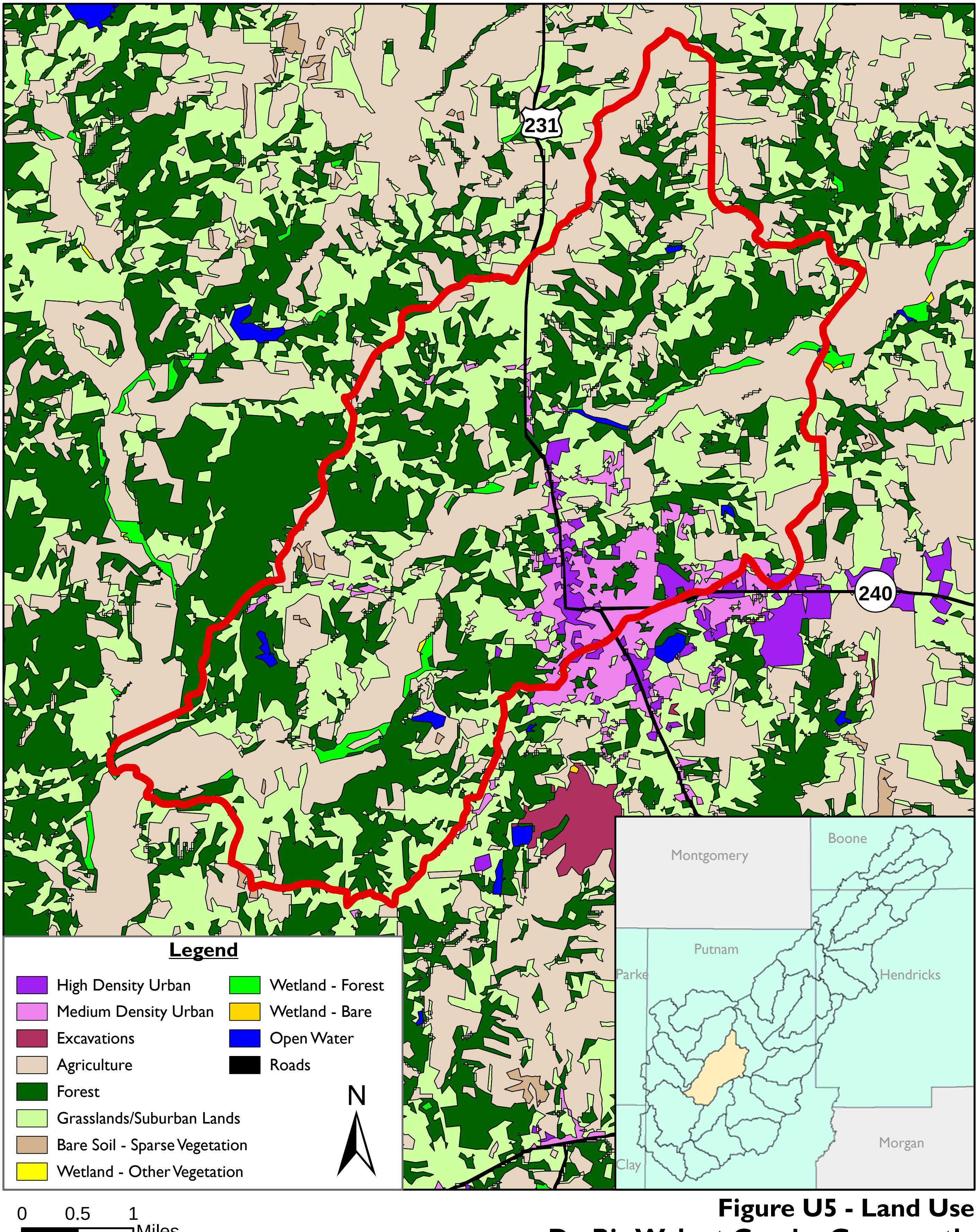



**Figure U5 - Land Use**
**D - Big Walnut Creek - Greencastle**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

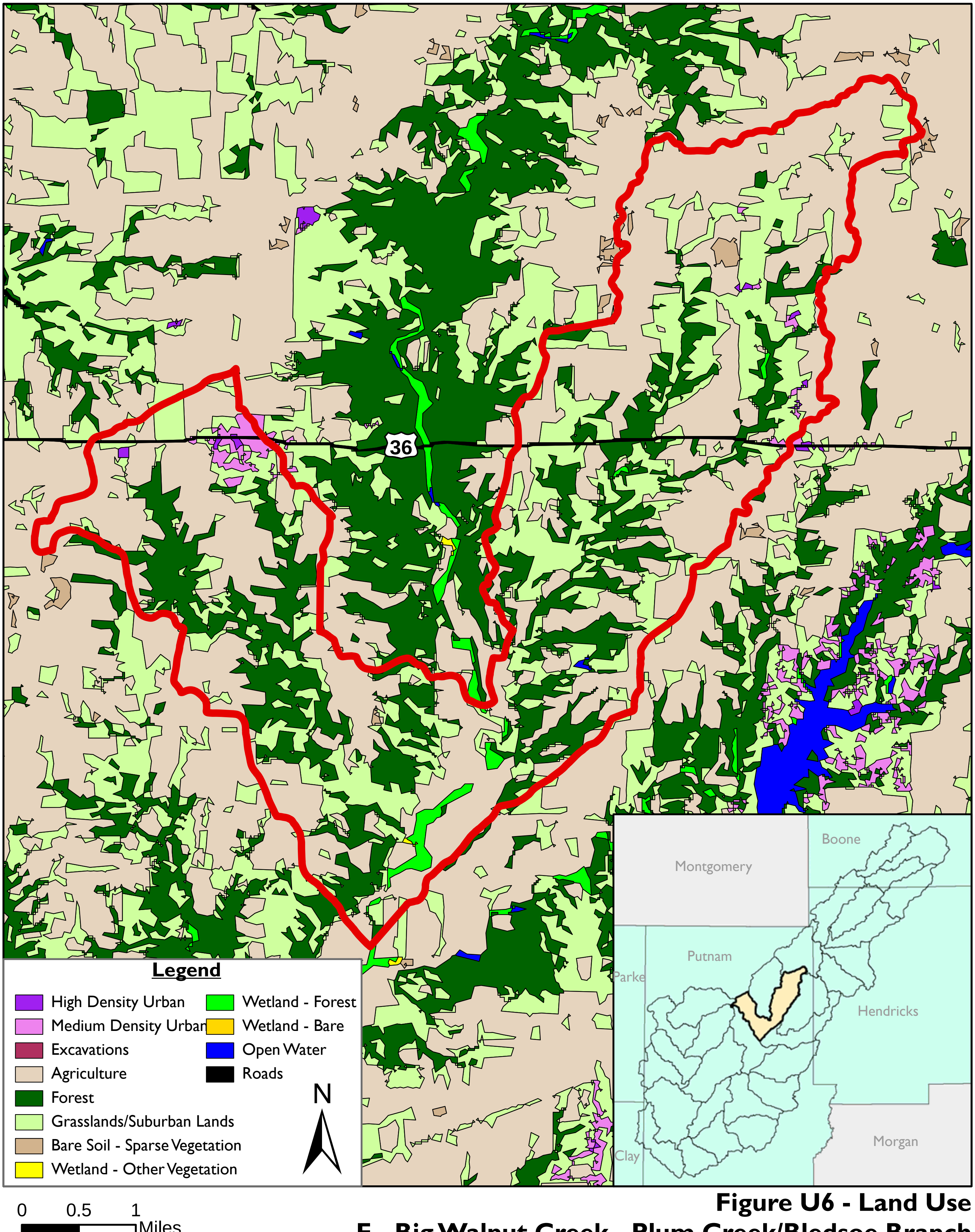



**Figure U6 - Land Use**
**F - Big Walnut Creek - Plum Creek/Bledsoe Branch**
**14-HUC Watershed**

Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

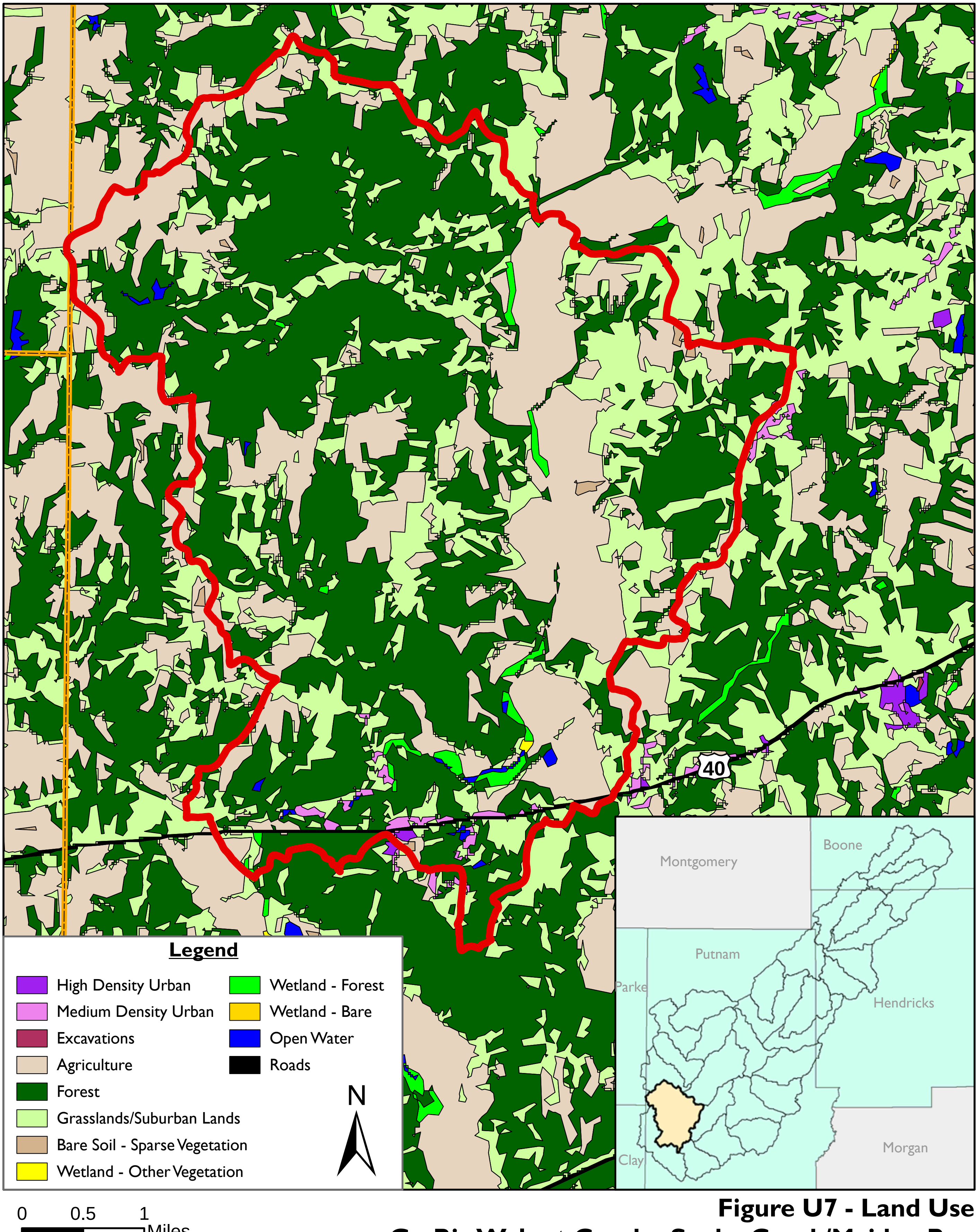



**Figure U7 - Land Use**
**G - Big Walnut Creek - Snake Creek/Maiden Run**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

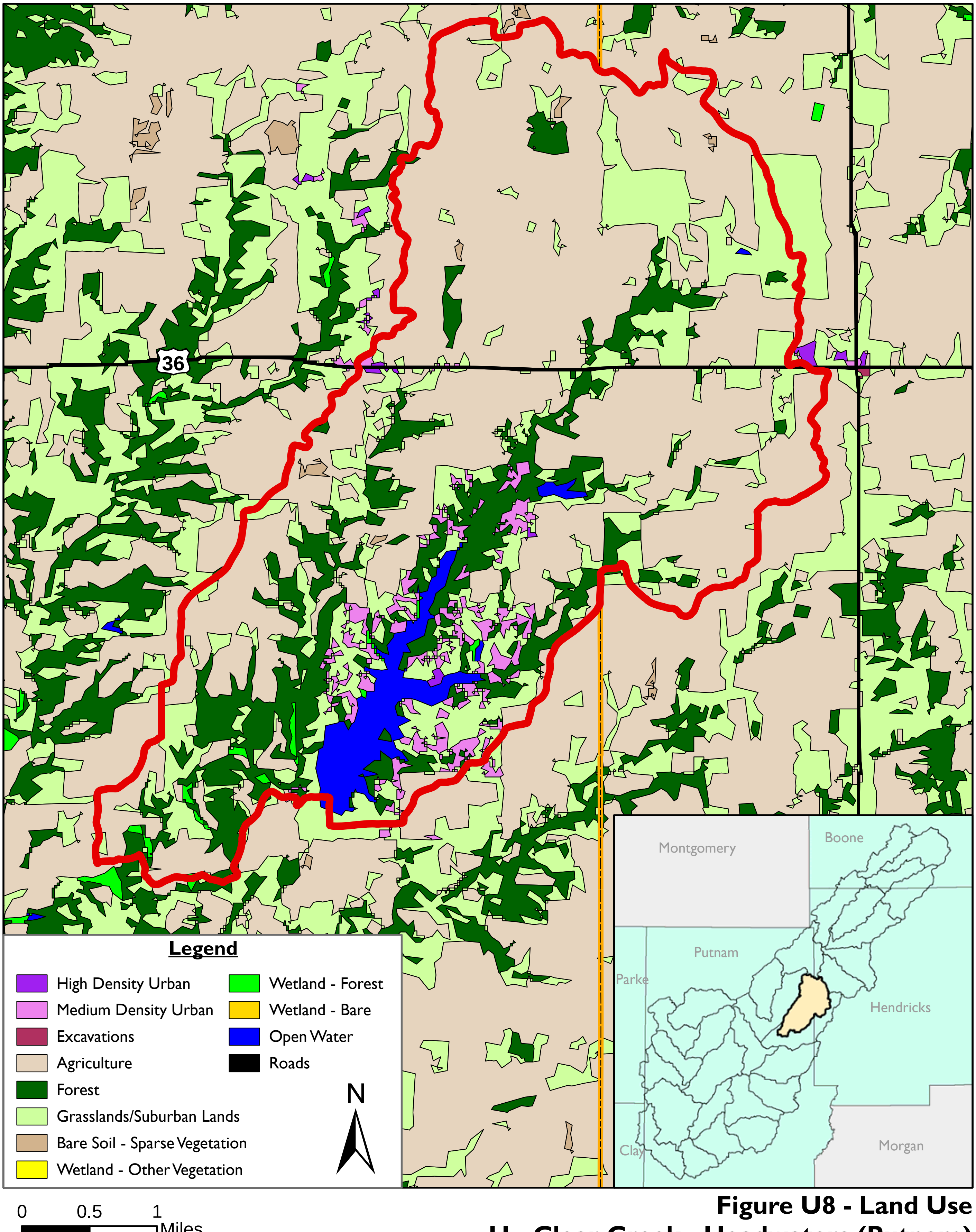



**Figure U8 - Land Use**
**H - Clear Creek - Headwaters (Putnam)**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

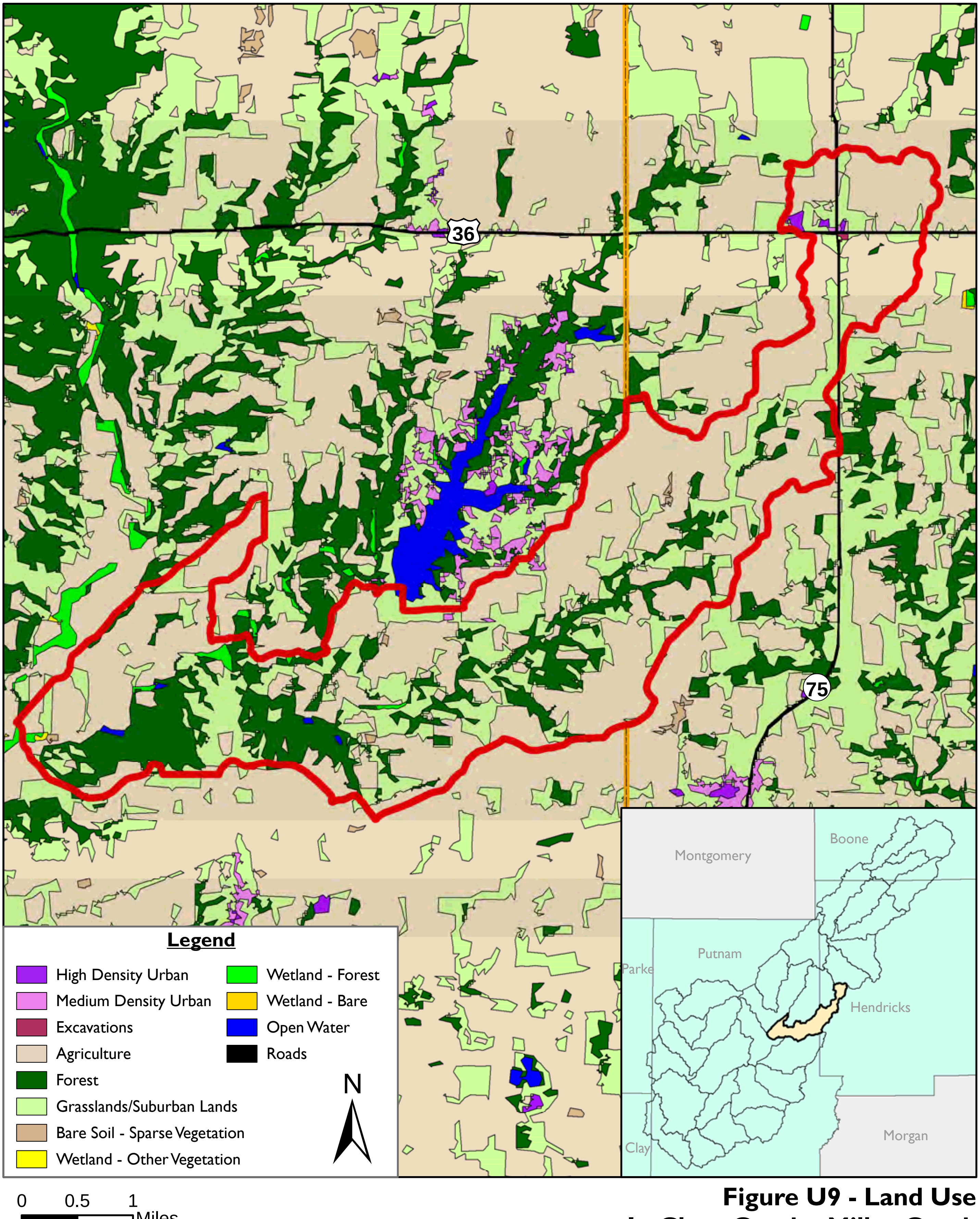



**Figure U9 - Land Use**
**1 - Clear Creek - Miller Creek**
**14-HUC Watershed**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

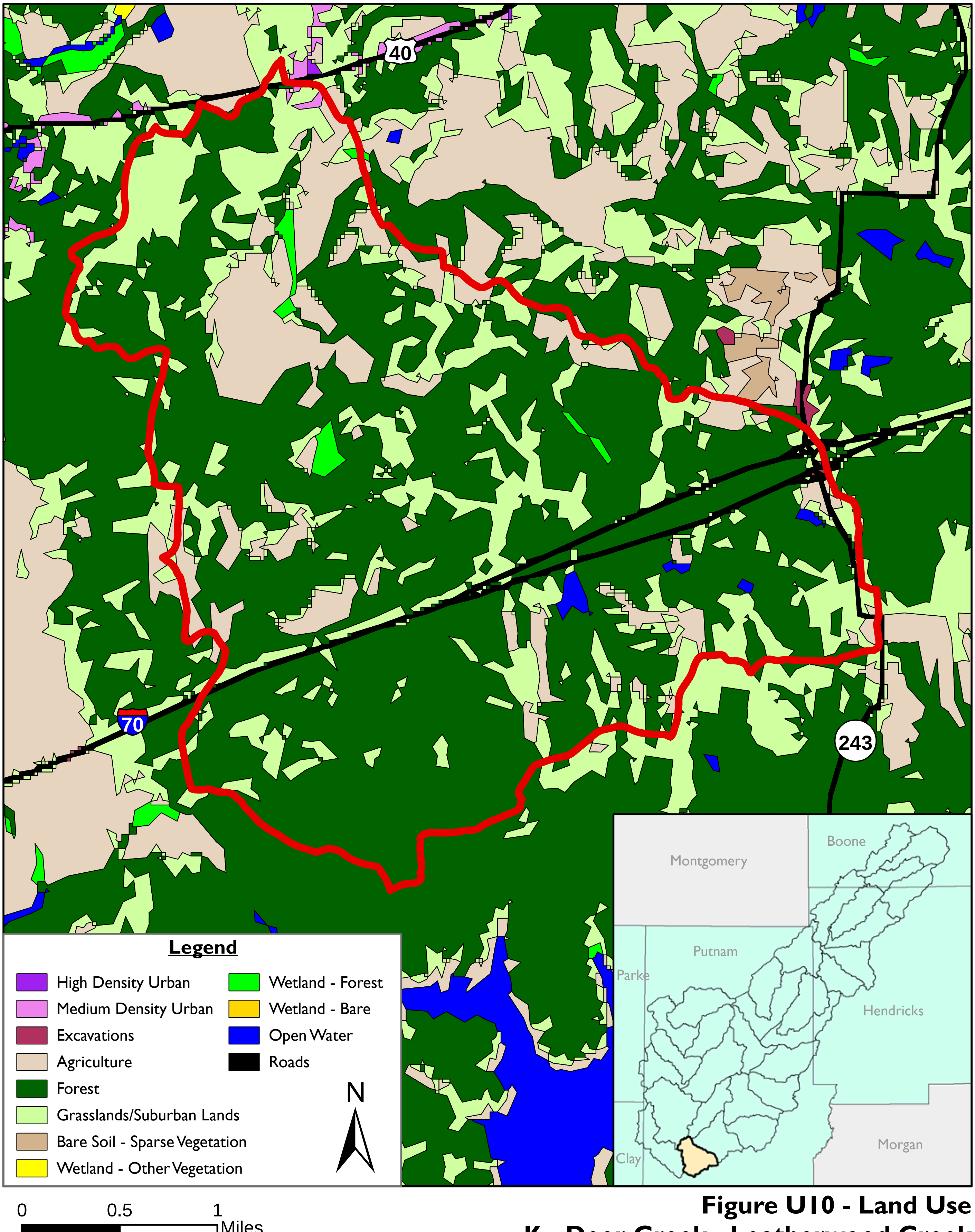



**Figure U10 - Land Use**
**K - Deer Creek - Leatherwood Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

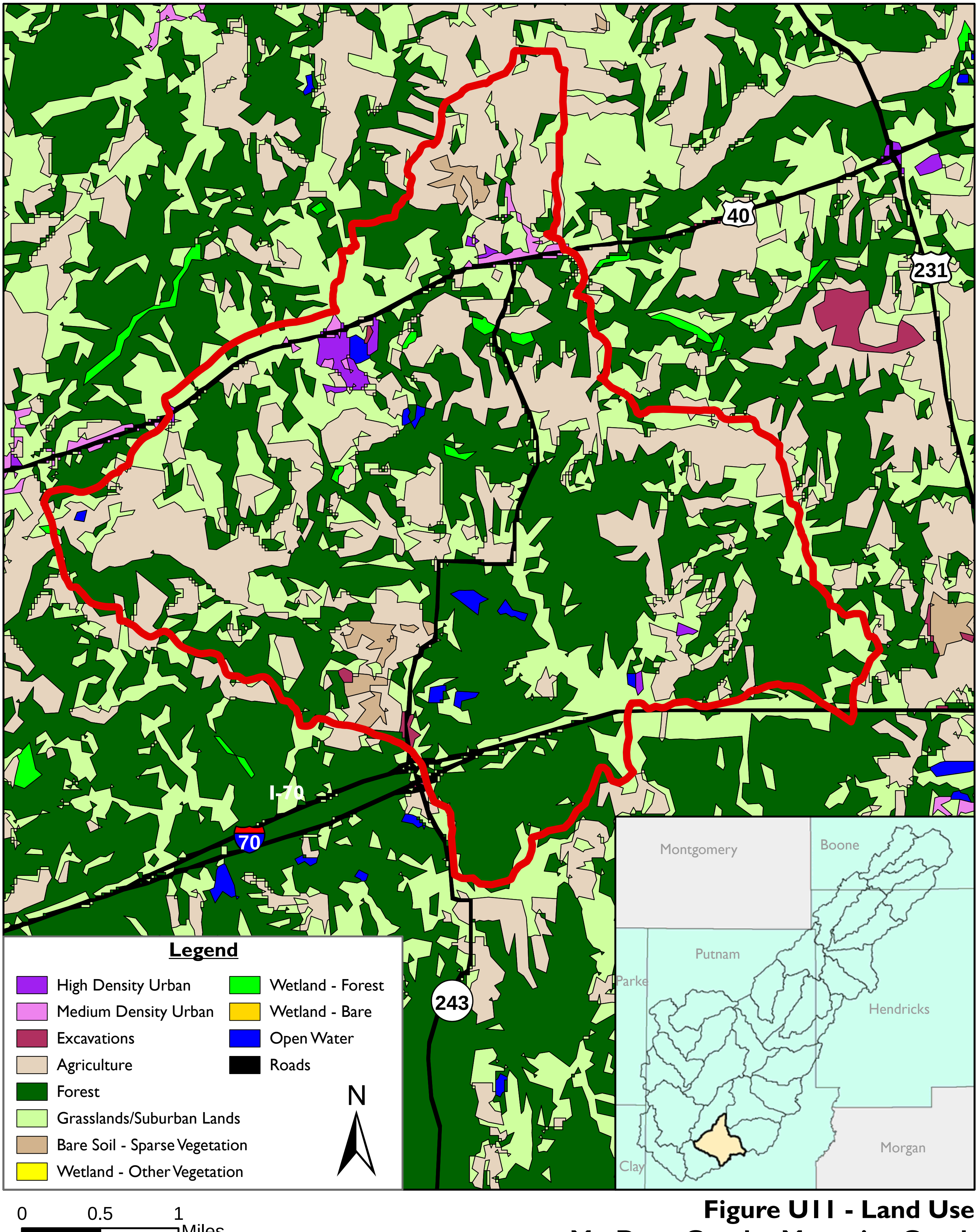



**Figure U11 - Land Use**
**M - Deer Creek - Mosquito Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

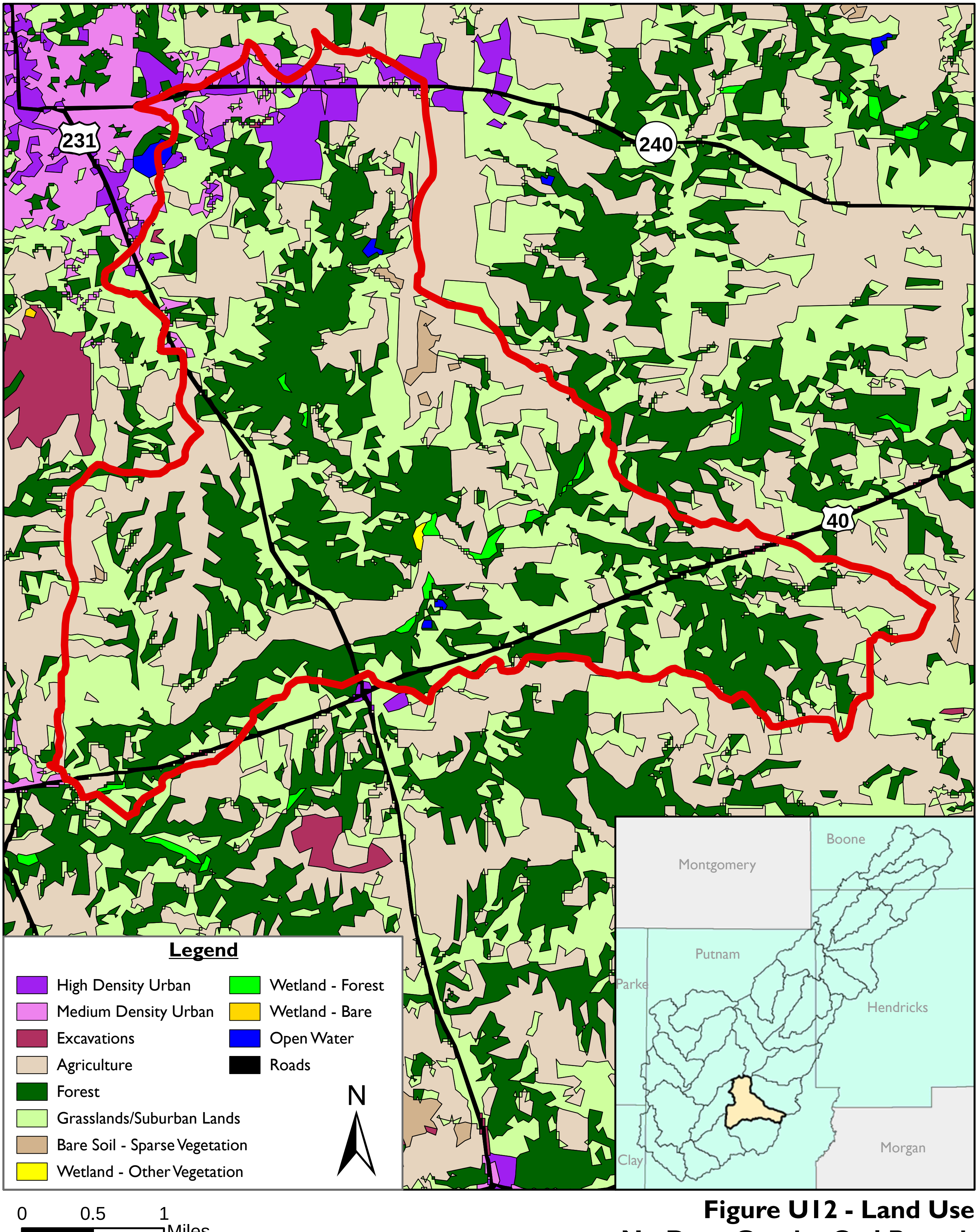
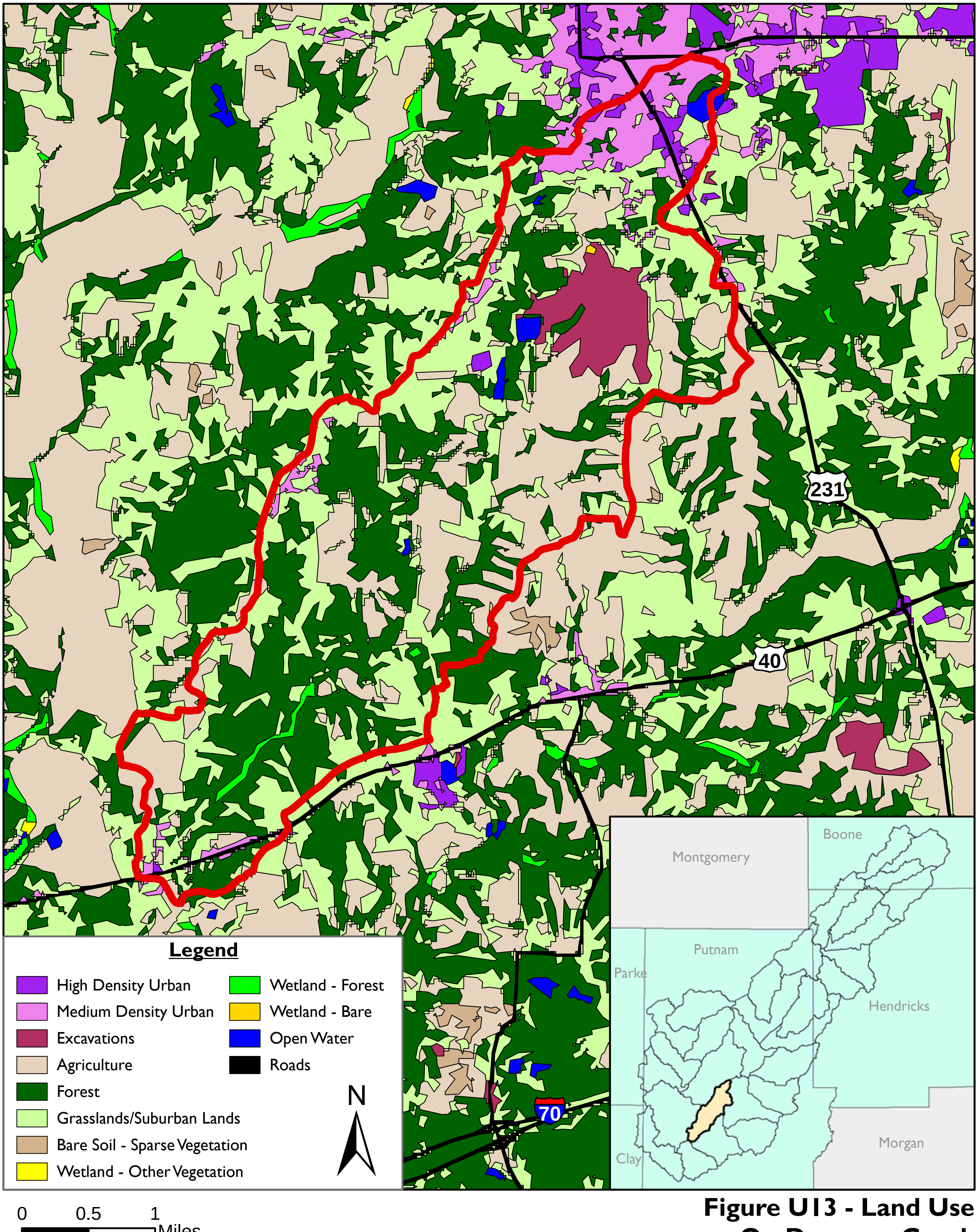



**Figure U12 - Land Use**
**N - Deer Creek - Owl Branch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana




# Figure U13 - Land Use
# O - Deweese Creek
# 14-HUC Watershed

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

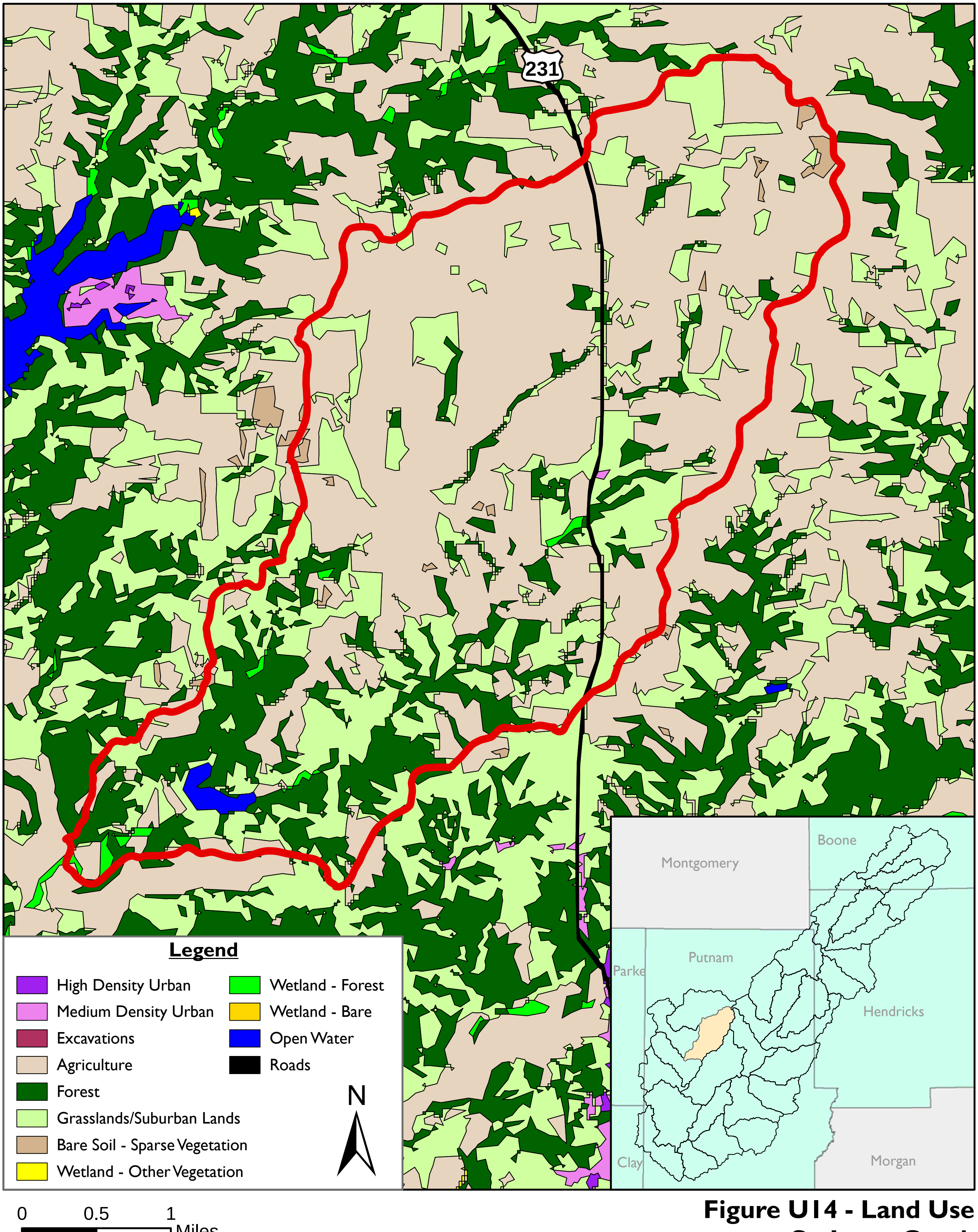



**Figure U14 - Land Use**
**S - Jones Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

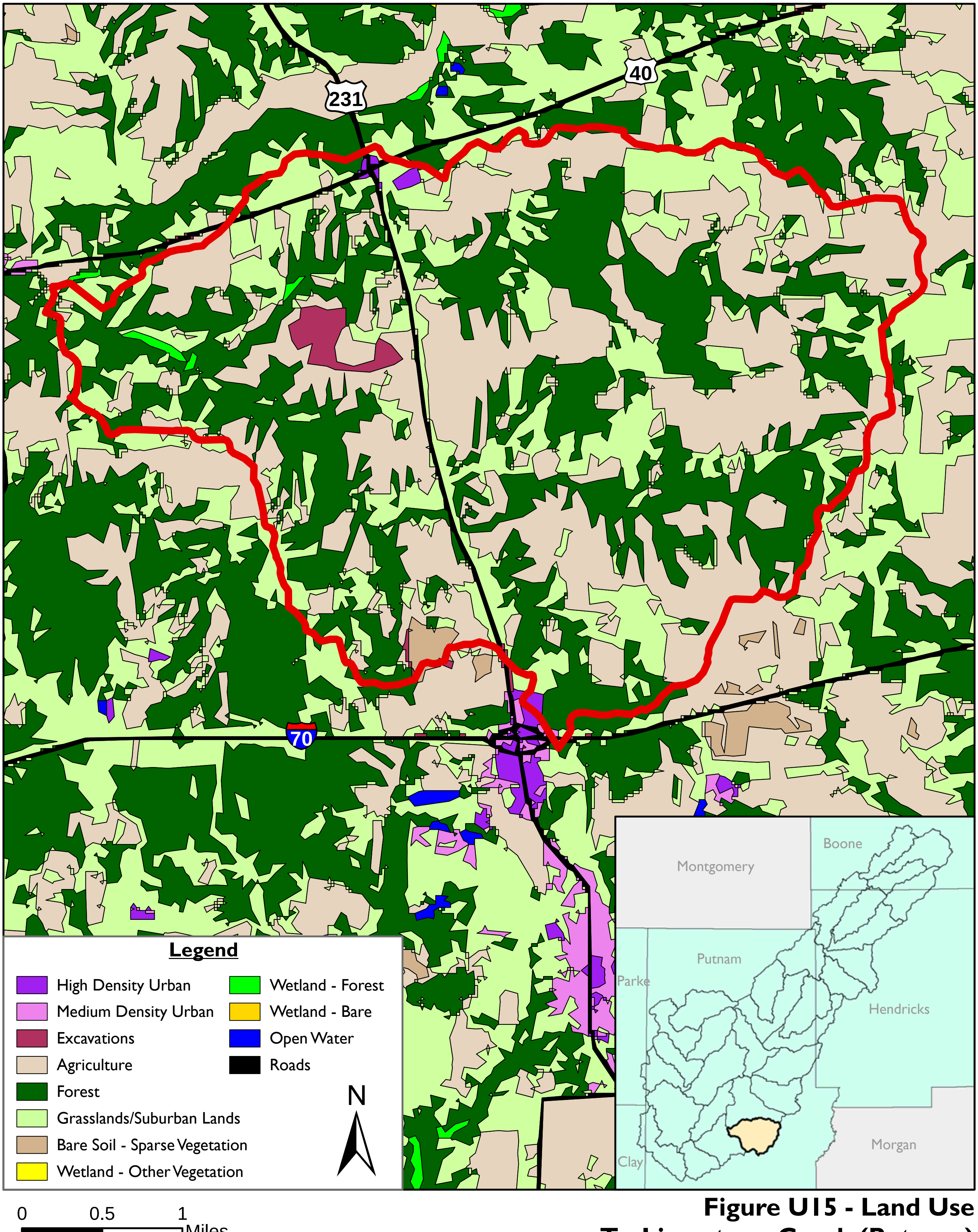



**Figure U15 - Land Use**
**T - Limestone Creek (Putnam)**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

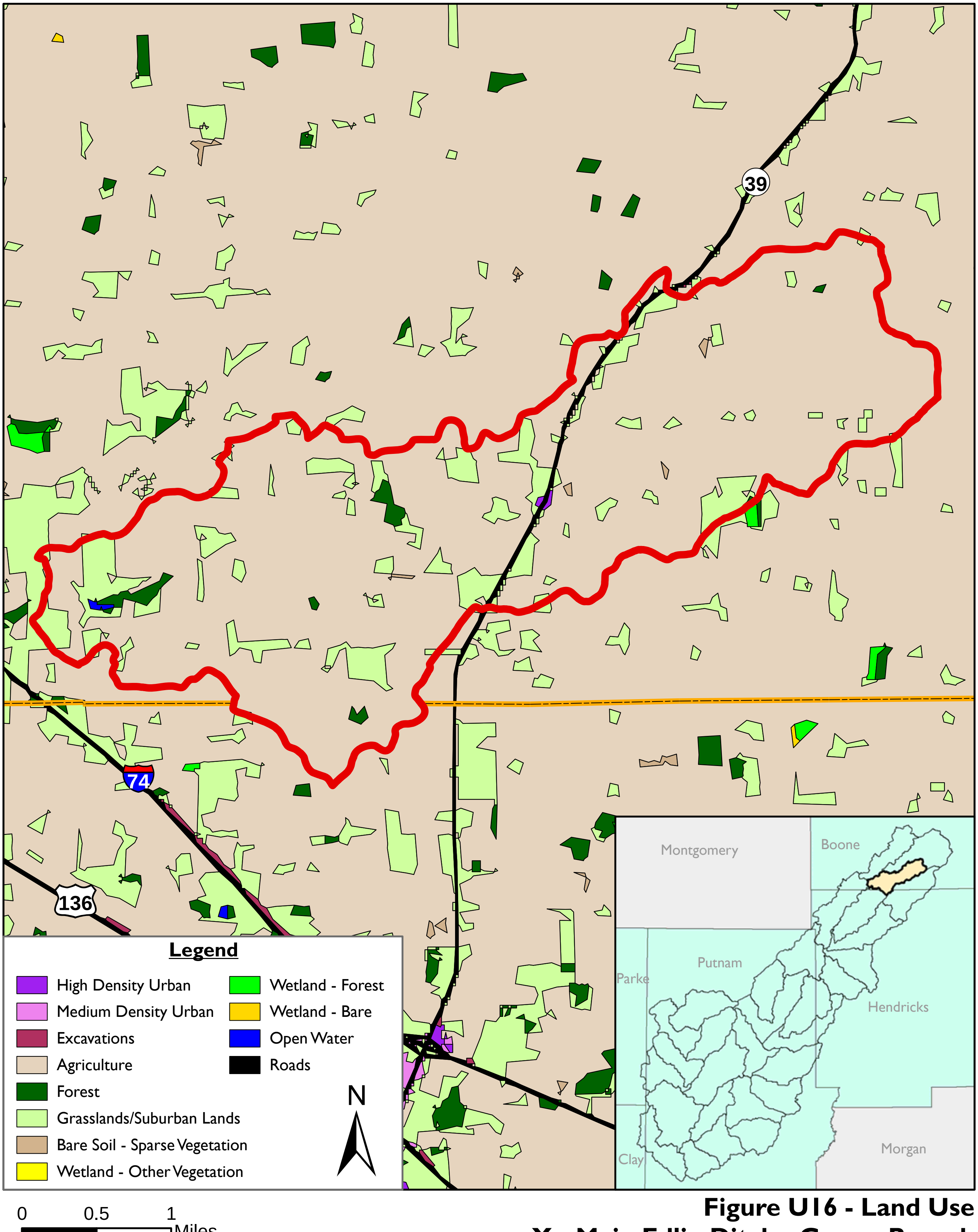



**Figure U16 - Land Use**
**X - Main Edlin Ditch - Grassy Branch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

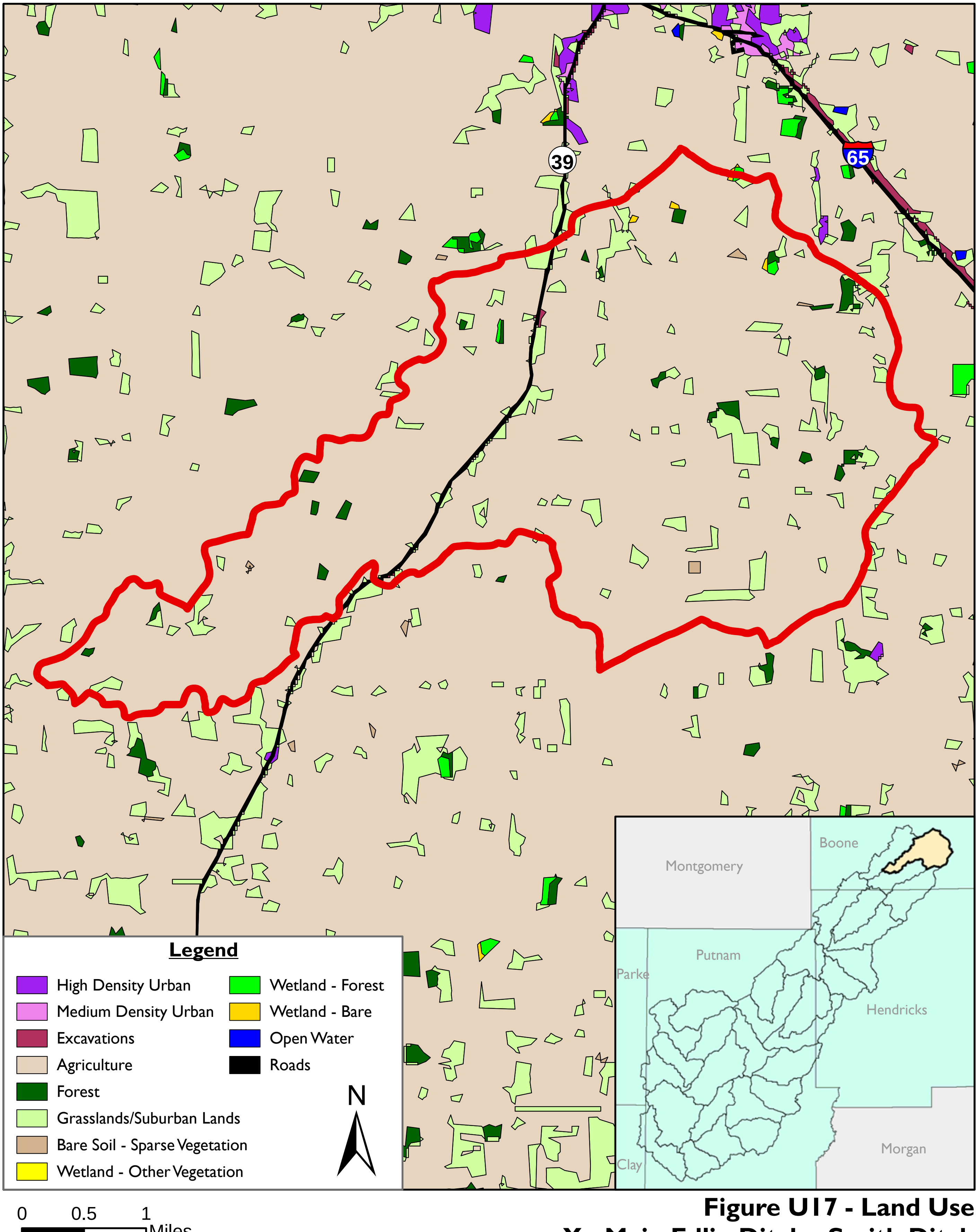



**Figure U17 - Land Use**
**Y - Main Edlin Ditch - Smith Ditch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

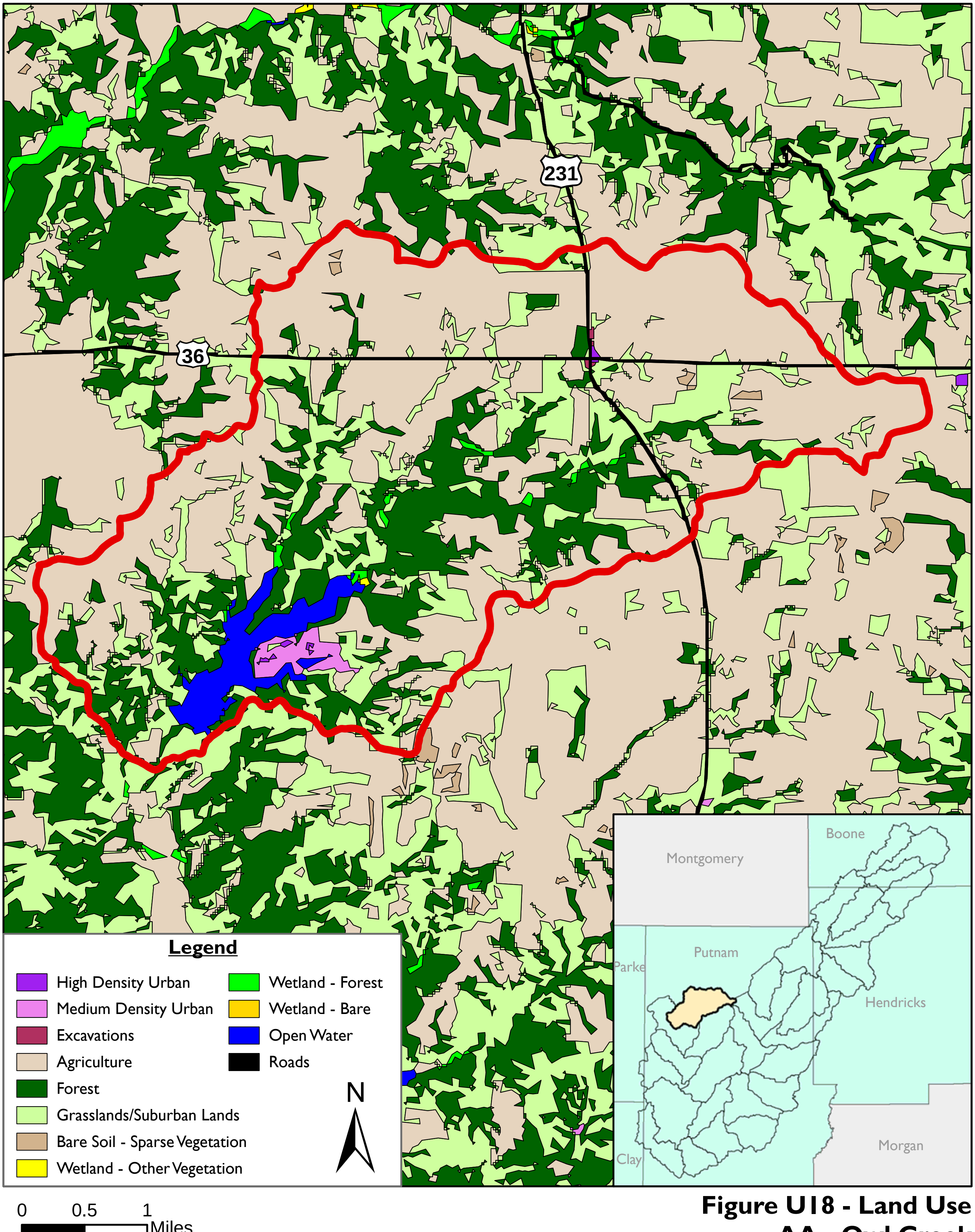



**Figure U18 - Land Use**
**AA - Owl Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

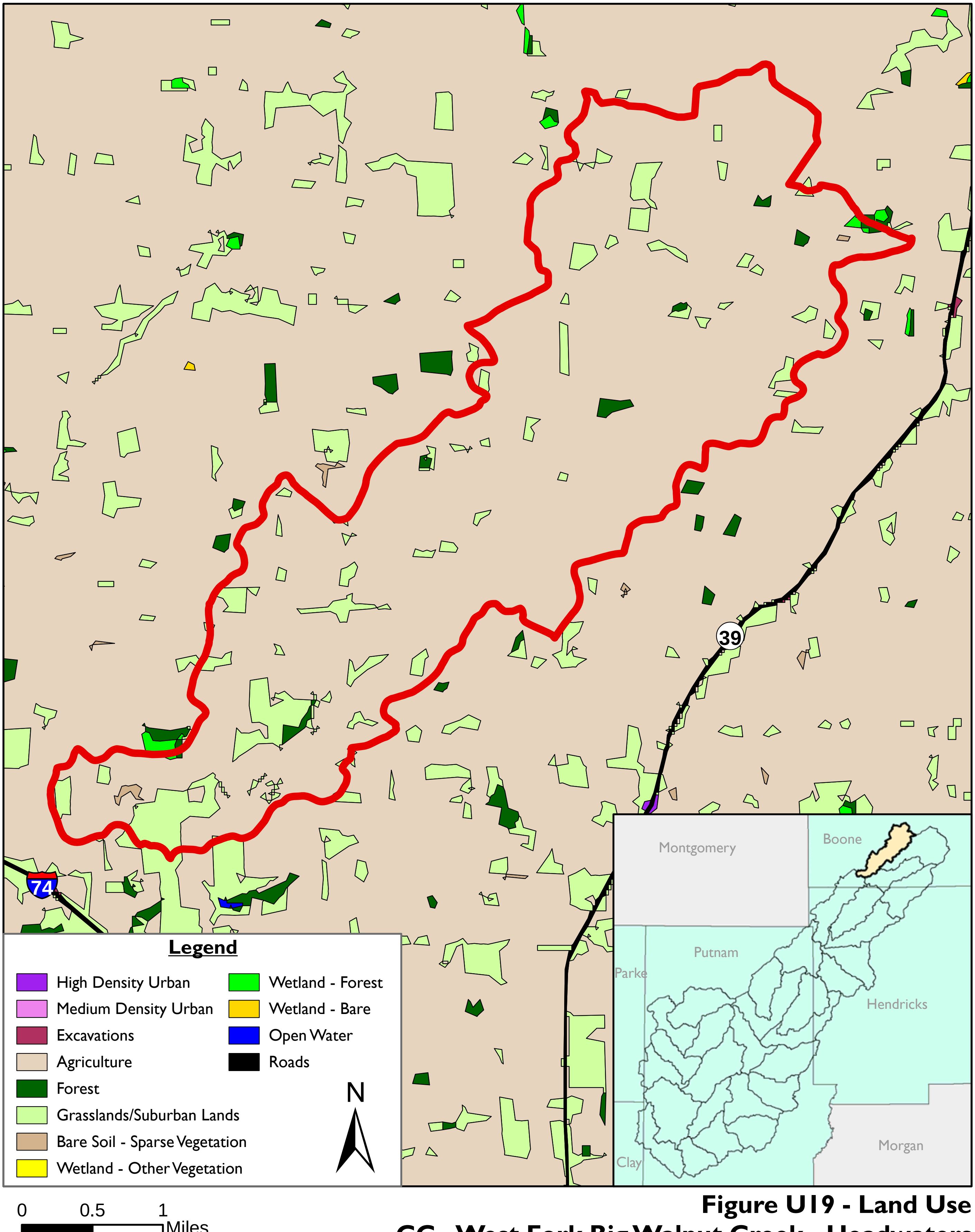



**Figure U19 - Land Use**
**CC - West Fork Big Walnut Creek - Headwaters**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

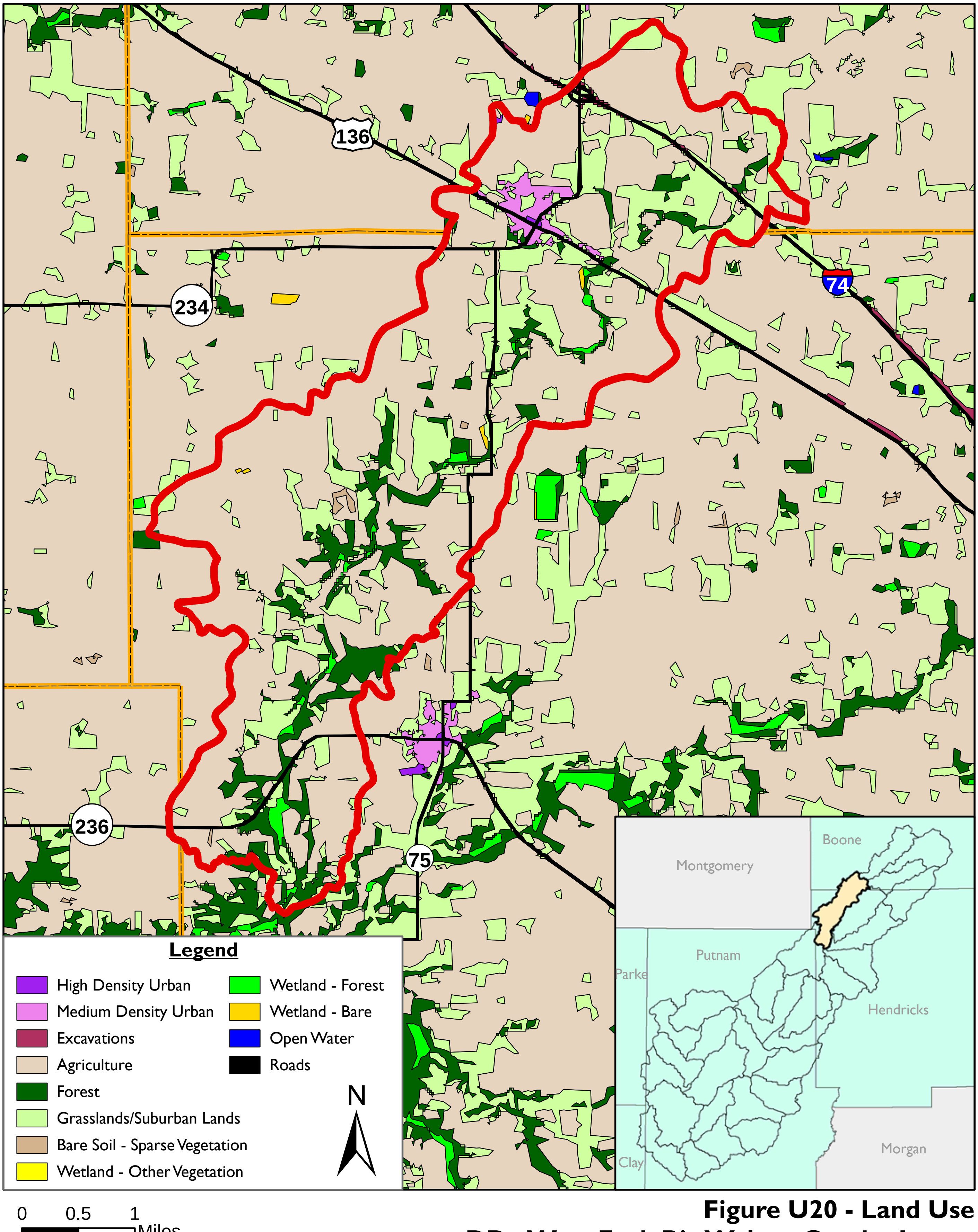



**Figure U20 - Land Use**
**DD - West Fork Big Walnut Creek - Lower**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

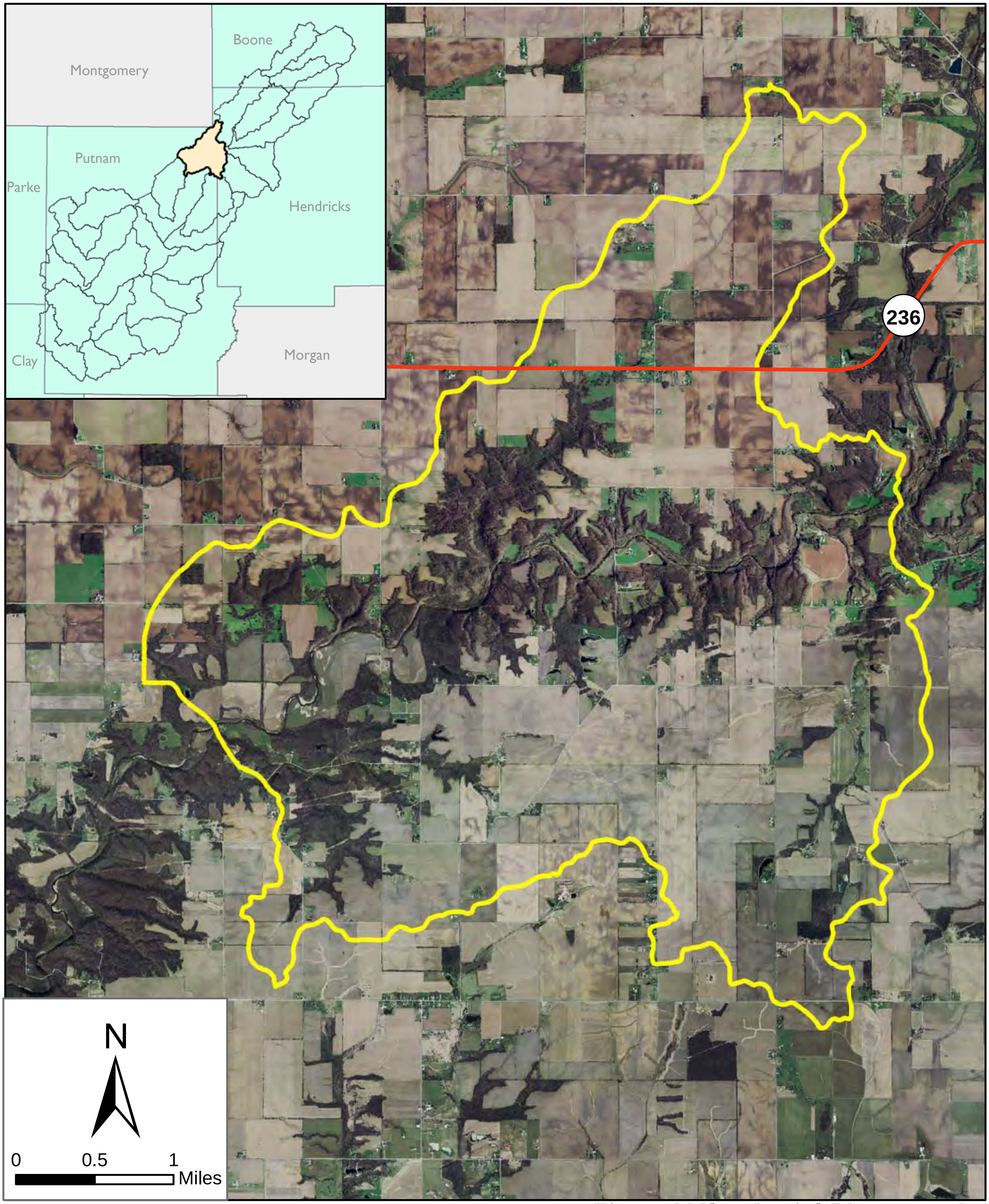



**Figure W1 - Aerial Photography**
**A - Big Walnut Creek - Barnard**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

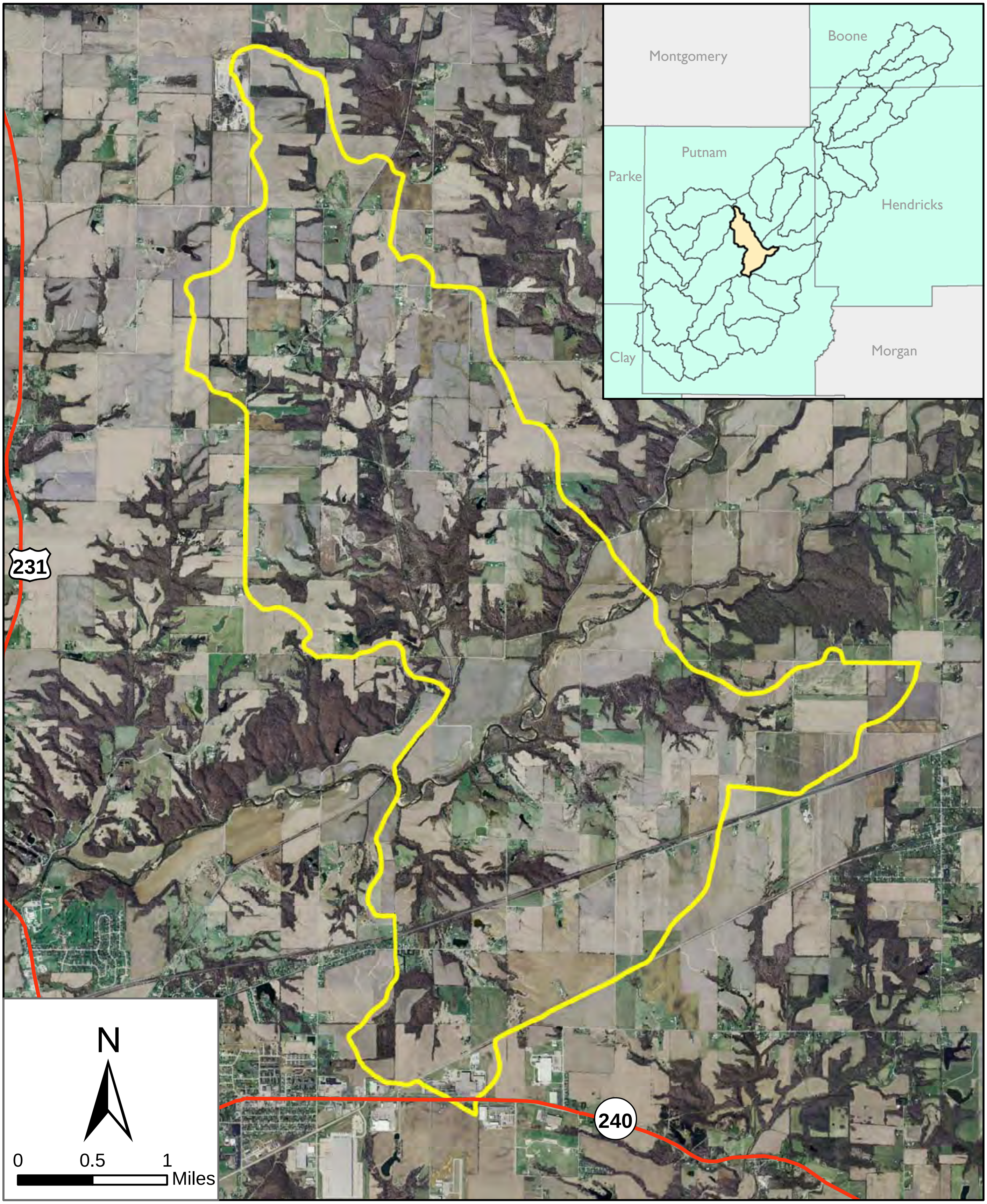



**Figure W2 - Aerial Photography**
**B - Big Walnut Creek - Dry Branch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

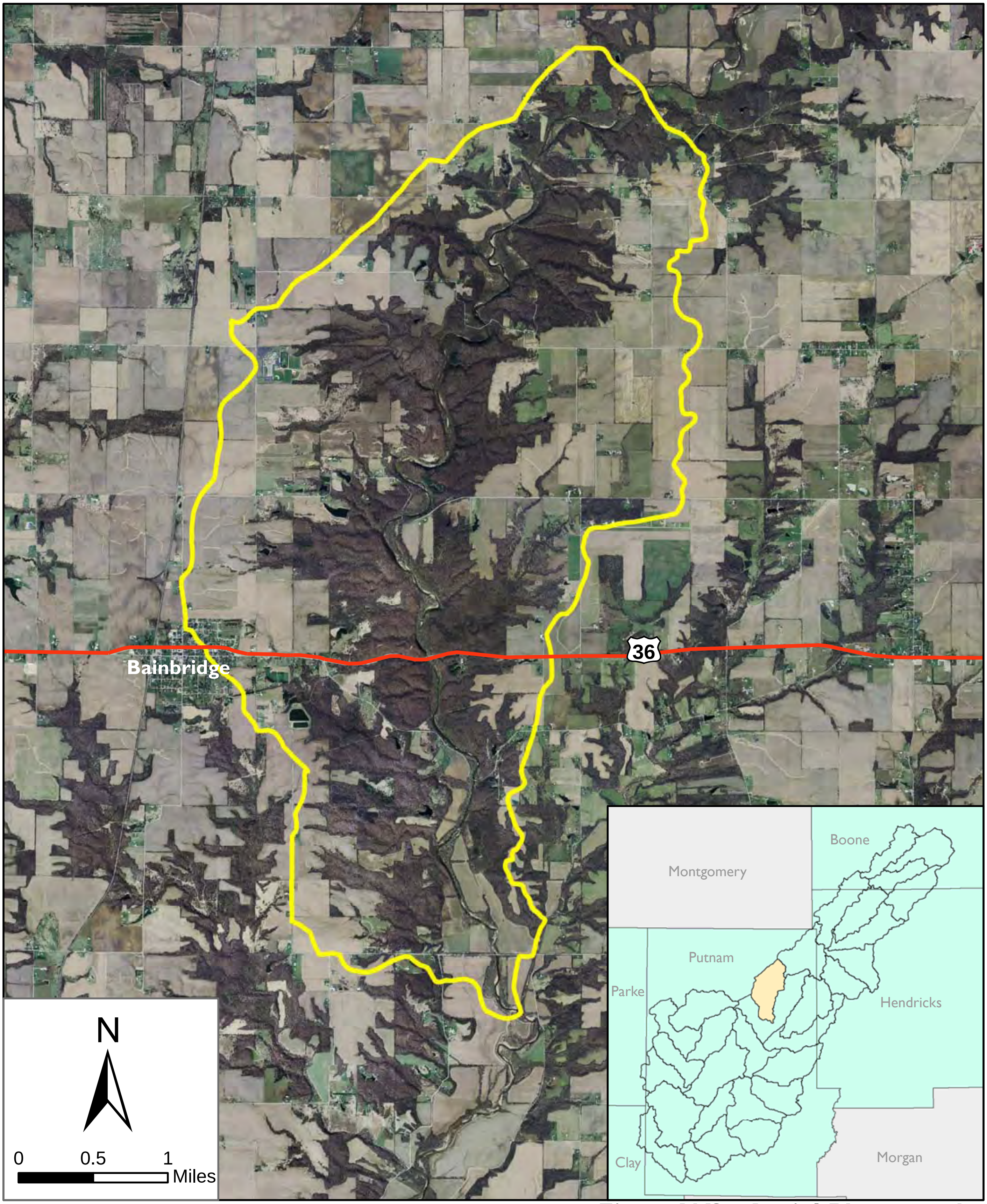



**Figure W3 - Aerial Photography**
**C - Big Walnut Creek - Ernie Pyle Memorial Hwy**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

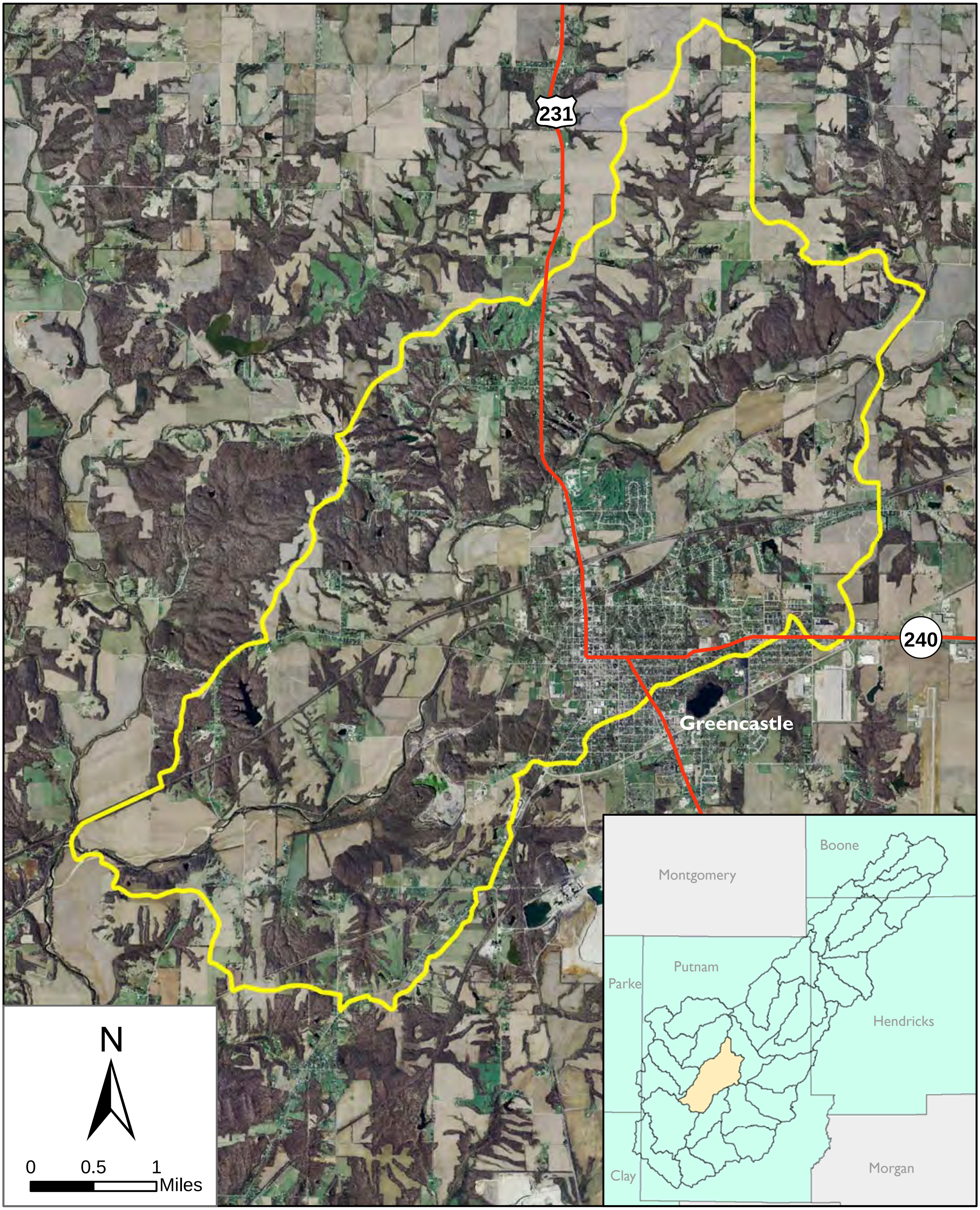



**Figure W4 - Aerial Photography**
**D - Big Walnut Creek - Greencastle**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

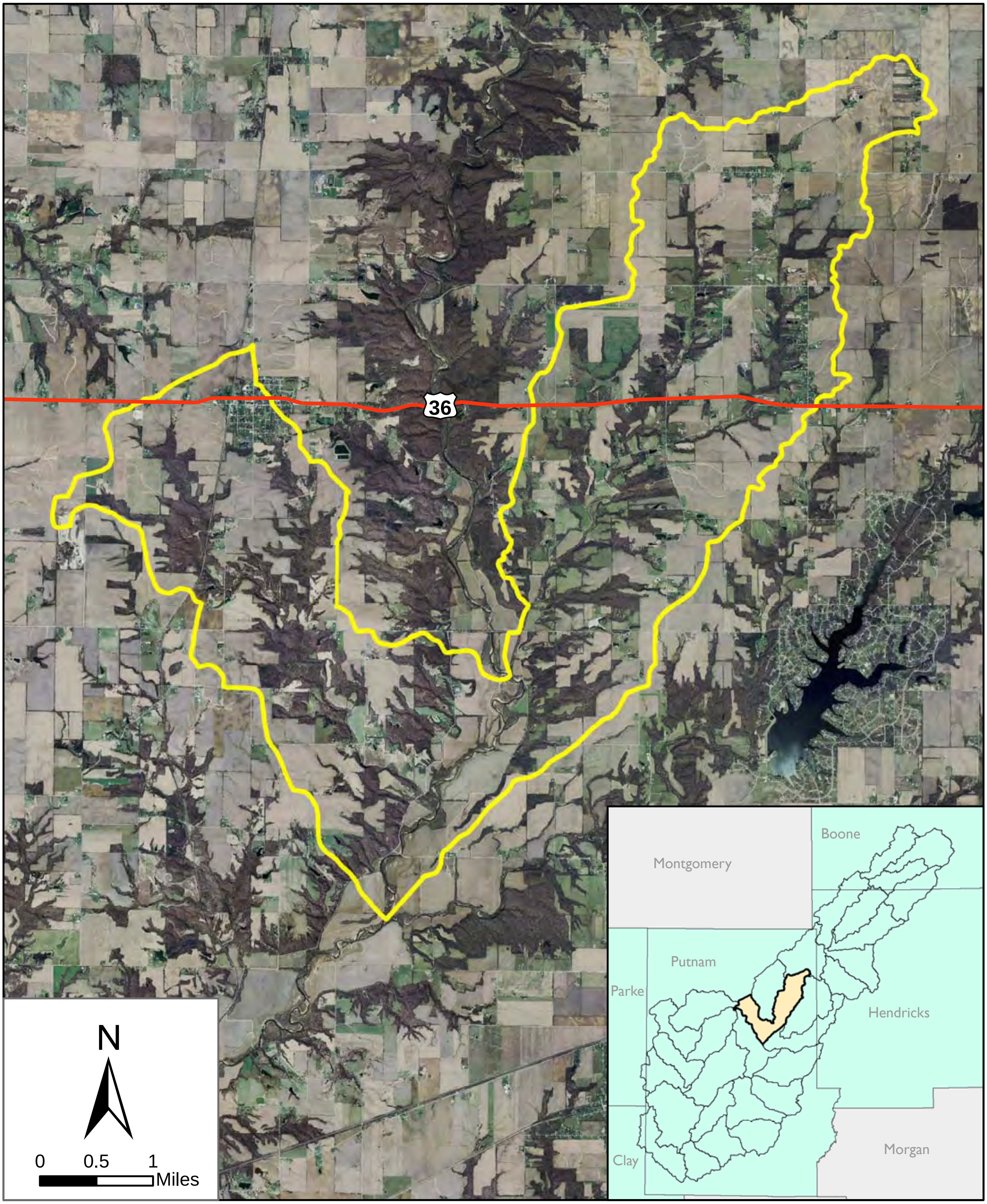



**Figure W5 - Aerial Photography**
**F - Big Walnut Creek - Plum Creek/Bledsoe Branch**
**14-HUC Watershed**

Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

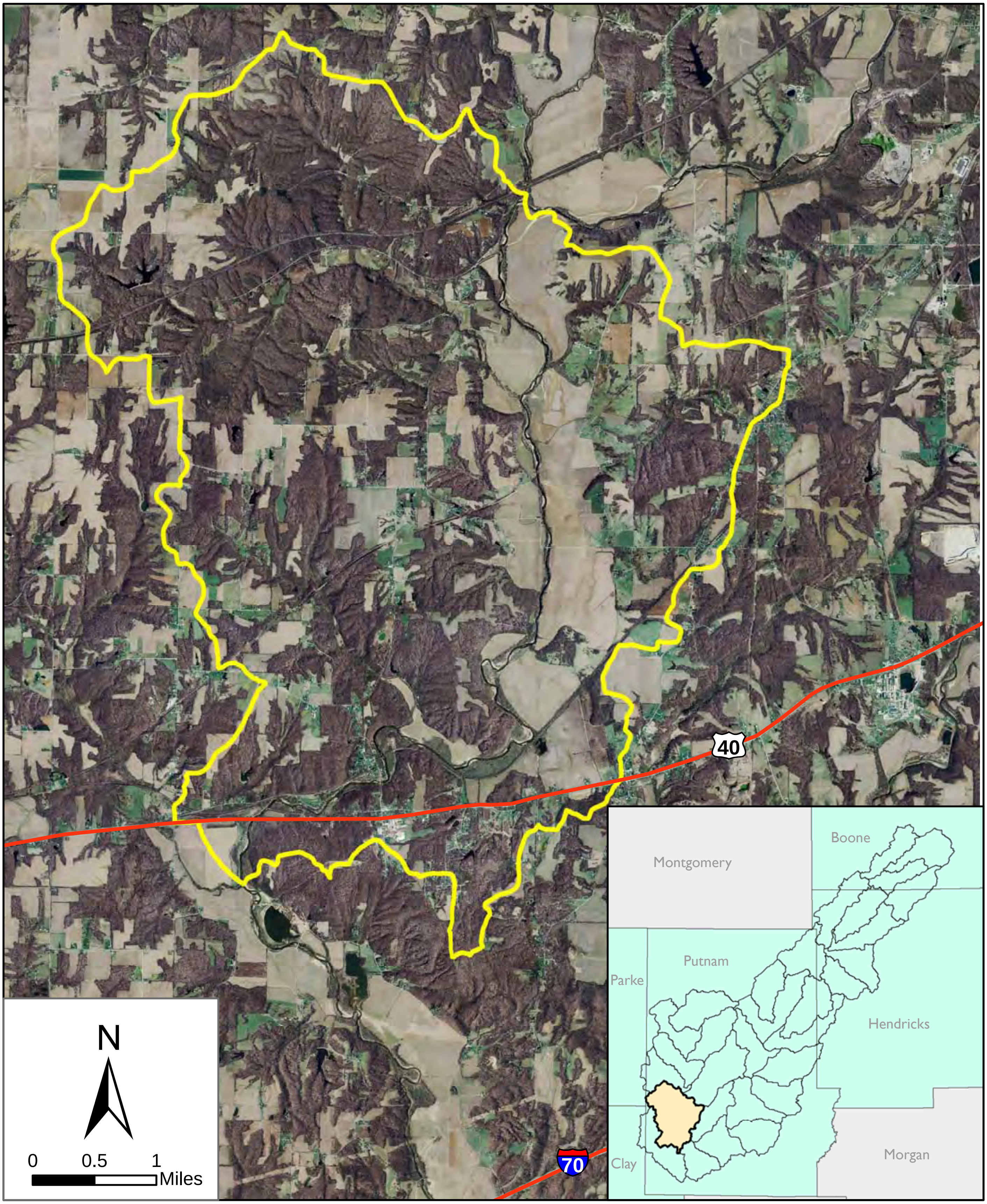



**Figure W6 - Aerial Photography**
**G - Big Walnut Creek - Snake Creek/Maiden Run**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

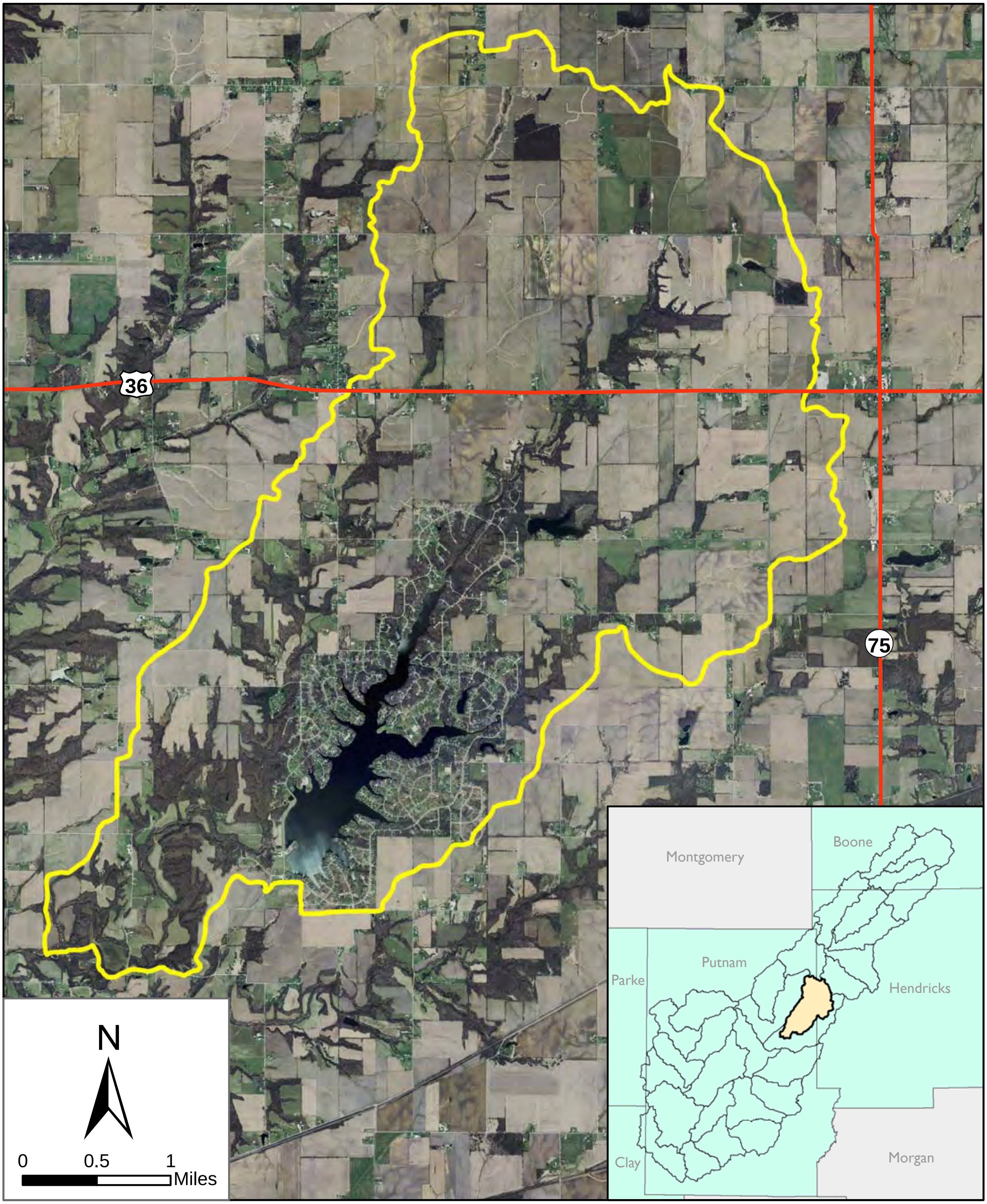



**Figure W7 - Aerial Photography**
**H - Clear Creek - Headwaters (Putnam)**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

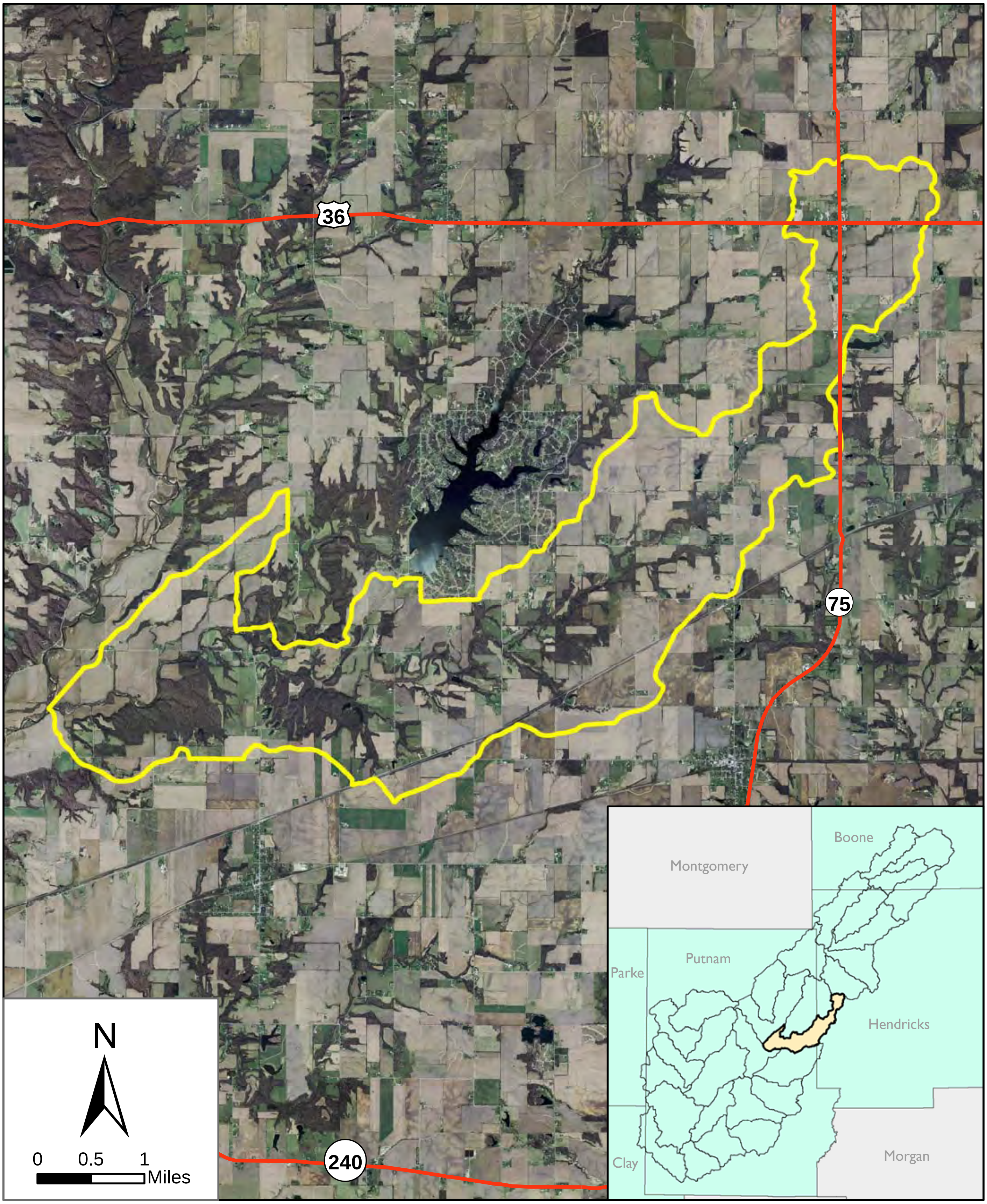



**Figure W8 - Aerial Photography**
**1 - Clear Creek - Miller Creek**
**14-HUC Watershed**

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

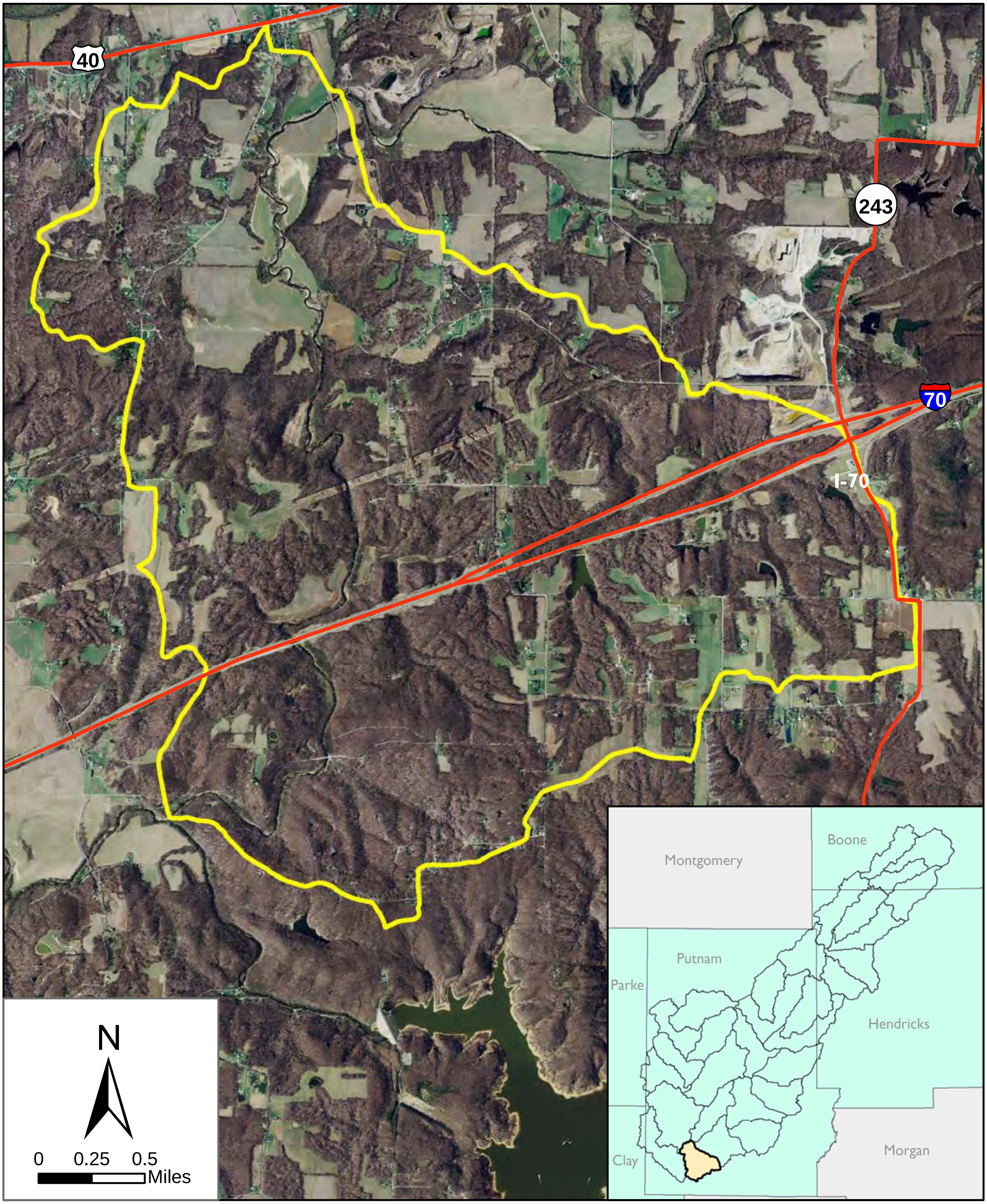



**Figure W9 - Aerial Photography**
**K - Deer Creek - Leatherwood Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

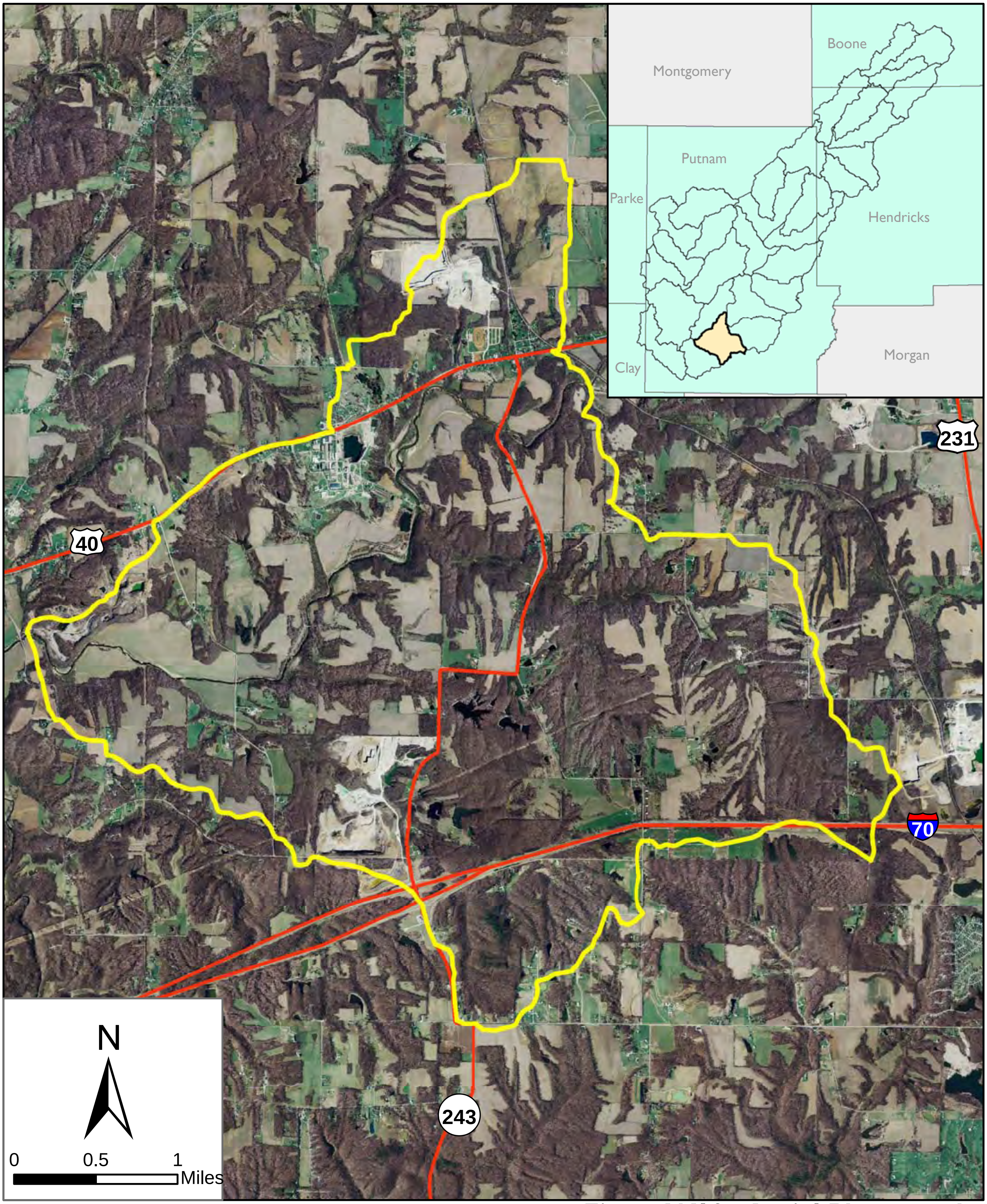



**Figure W10 - Aerial Photography**
**M - Deer Creek - Mosquito Creek**
**14-HUC Watershed**

Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

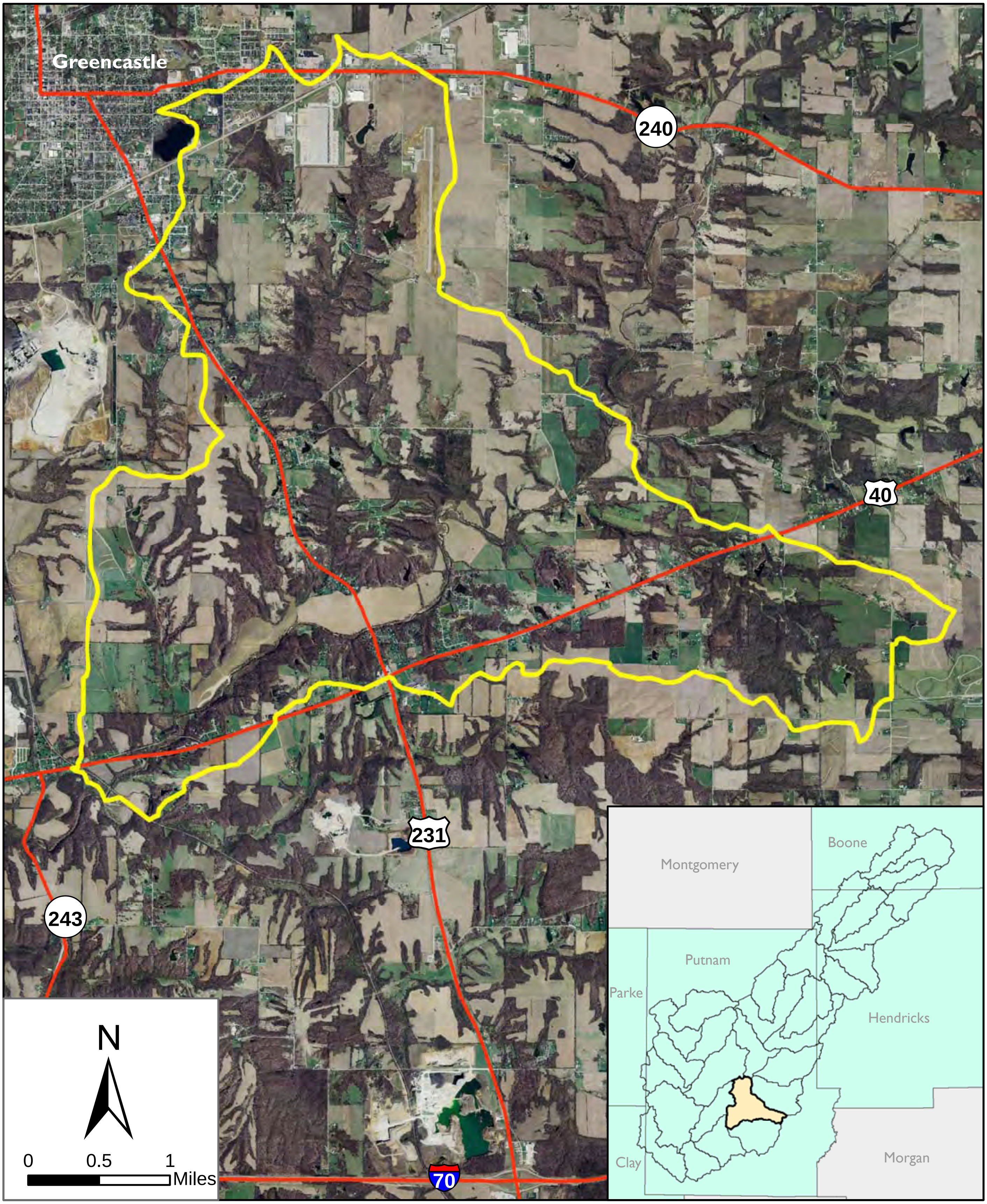



**Figure W11 - Aerial Photography**
**N - Deer Creek - Owl Branch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

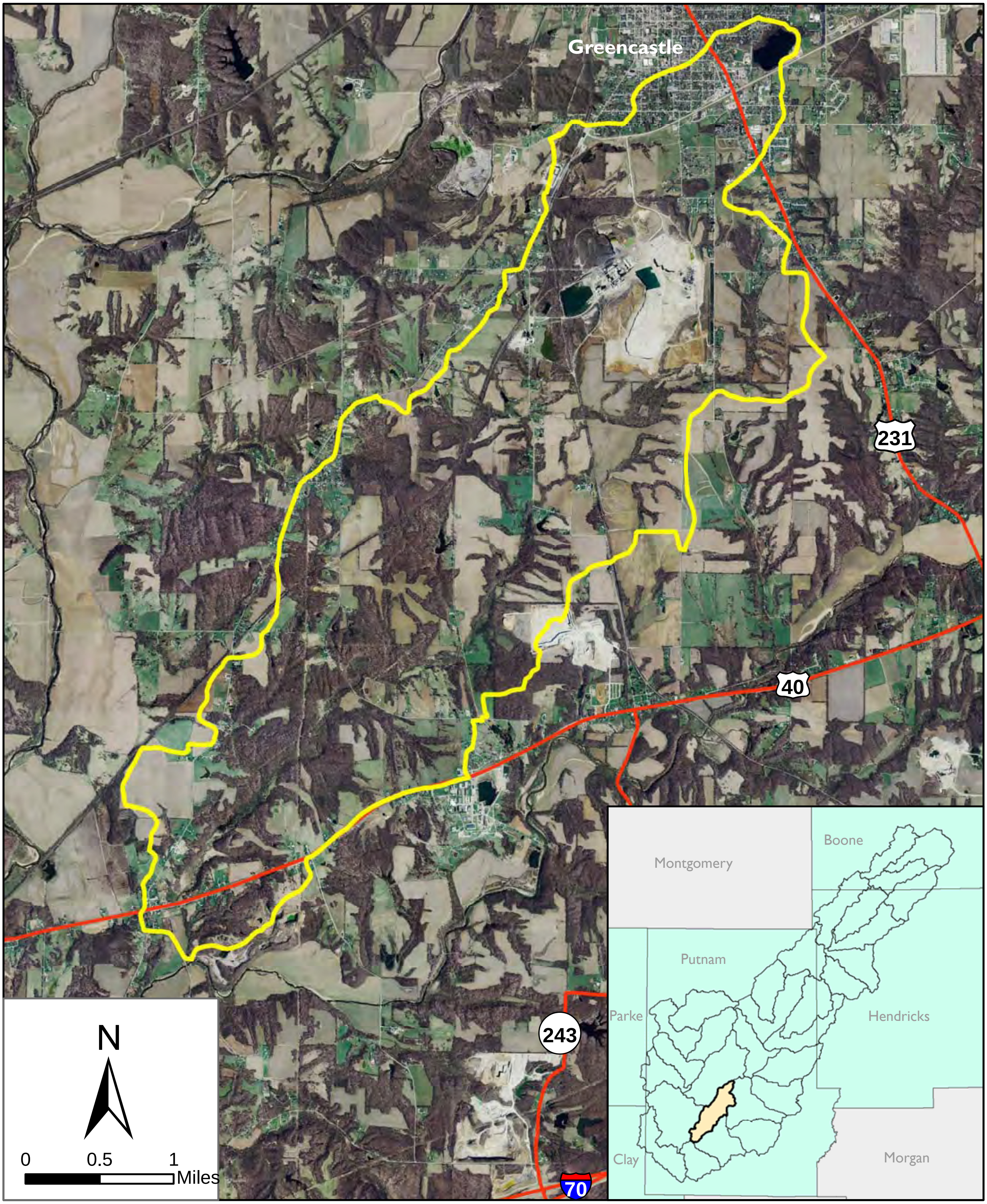



**Figure W12 - Aerial Photography**
**O - Deweese Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

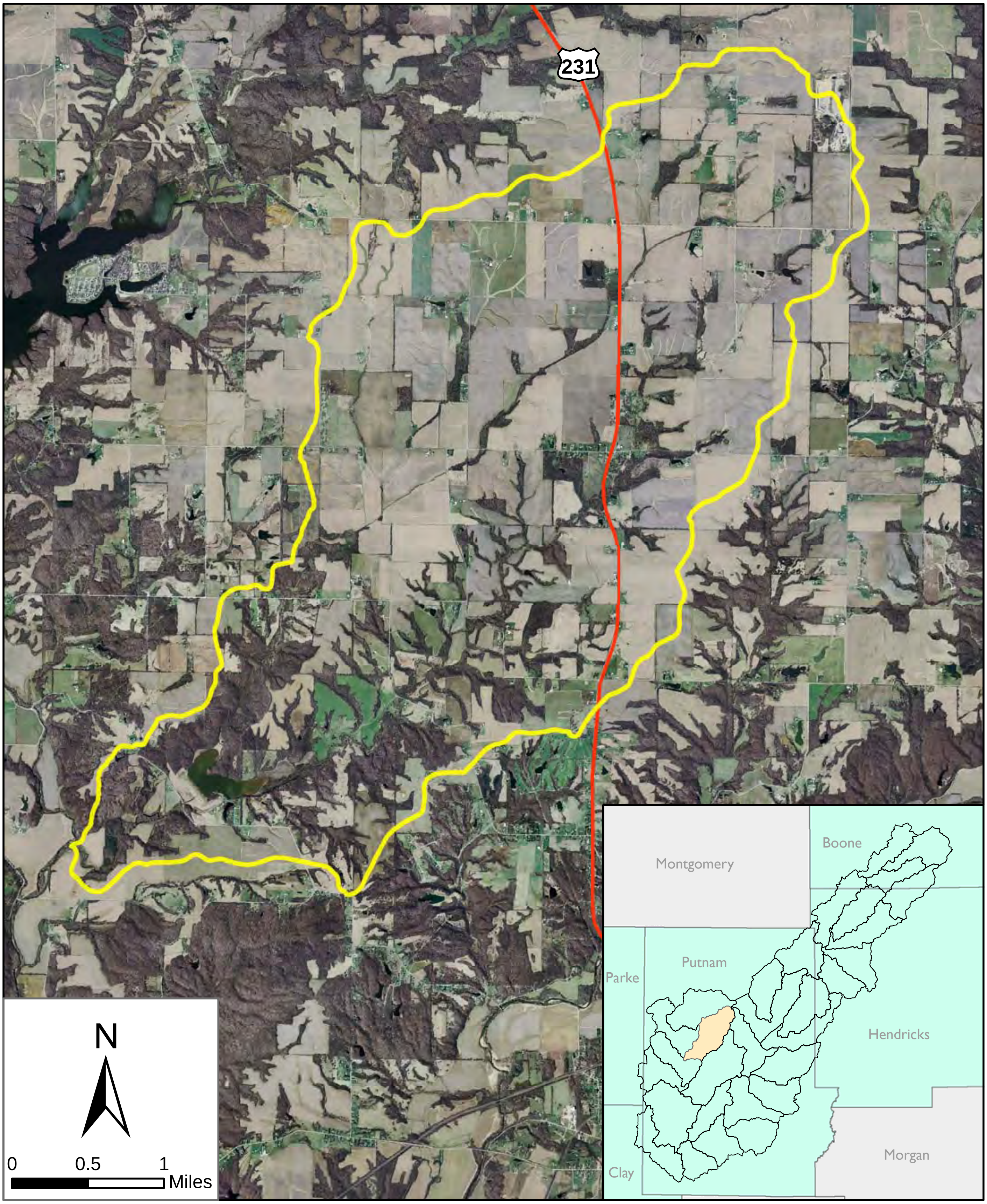



**Figure W13 - Aerial Photography**
**S - Jones Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

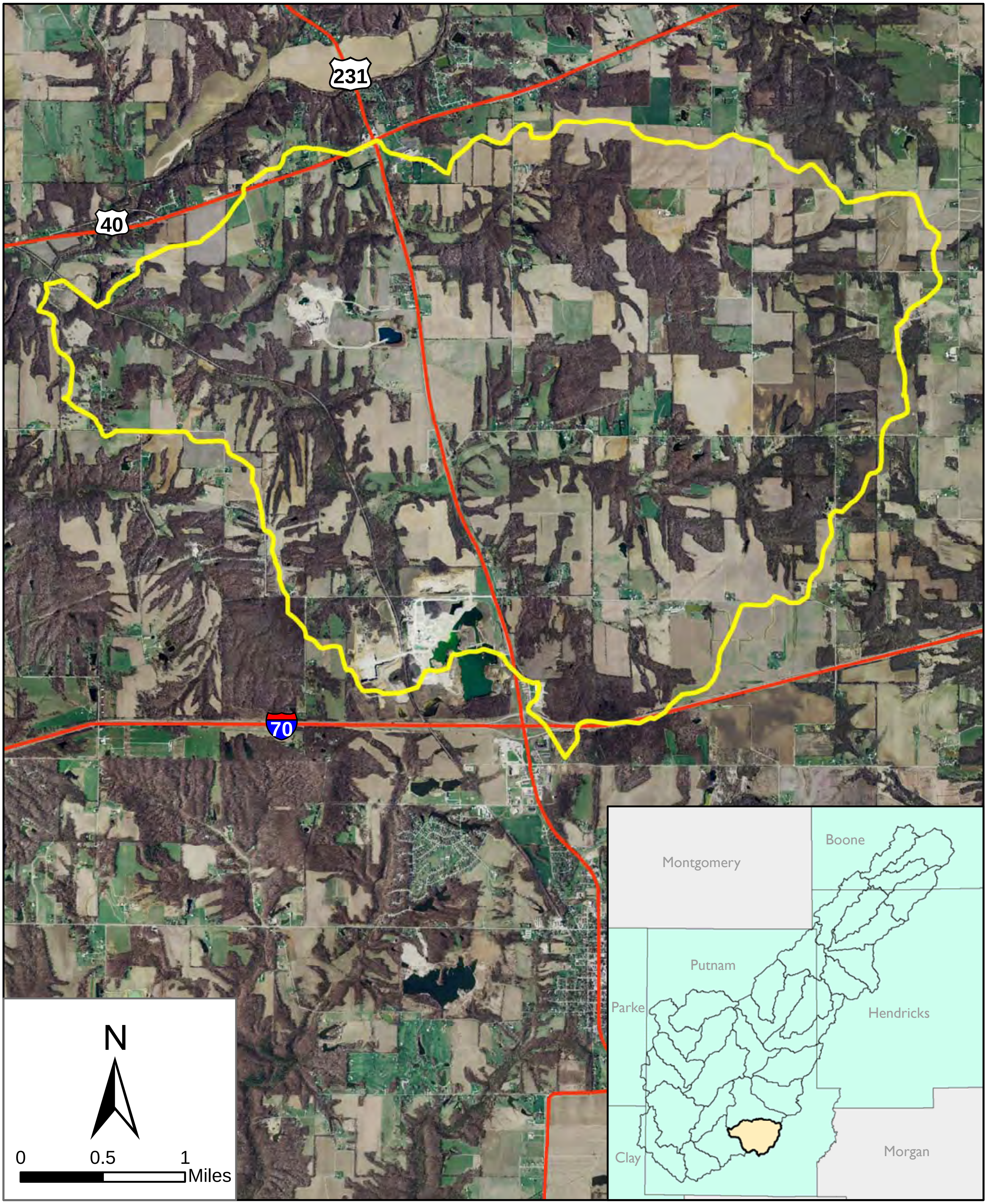



**Figure W14 - Aerial Photography**
**T - Limestone Creek (Putnam)**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

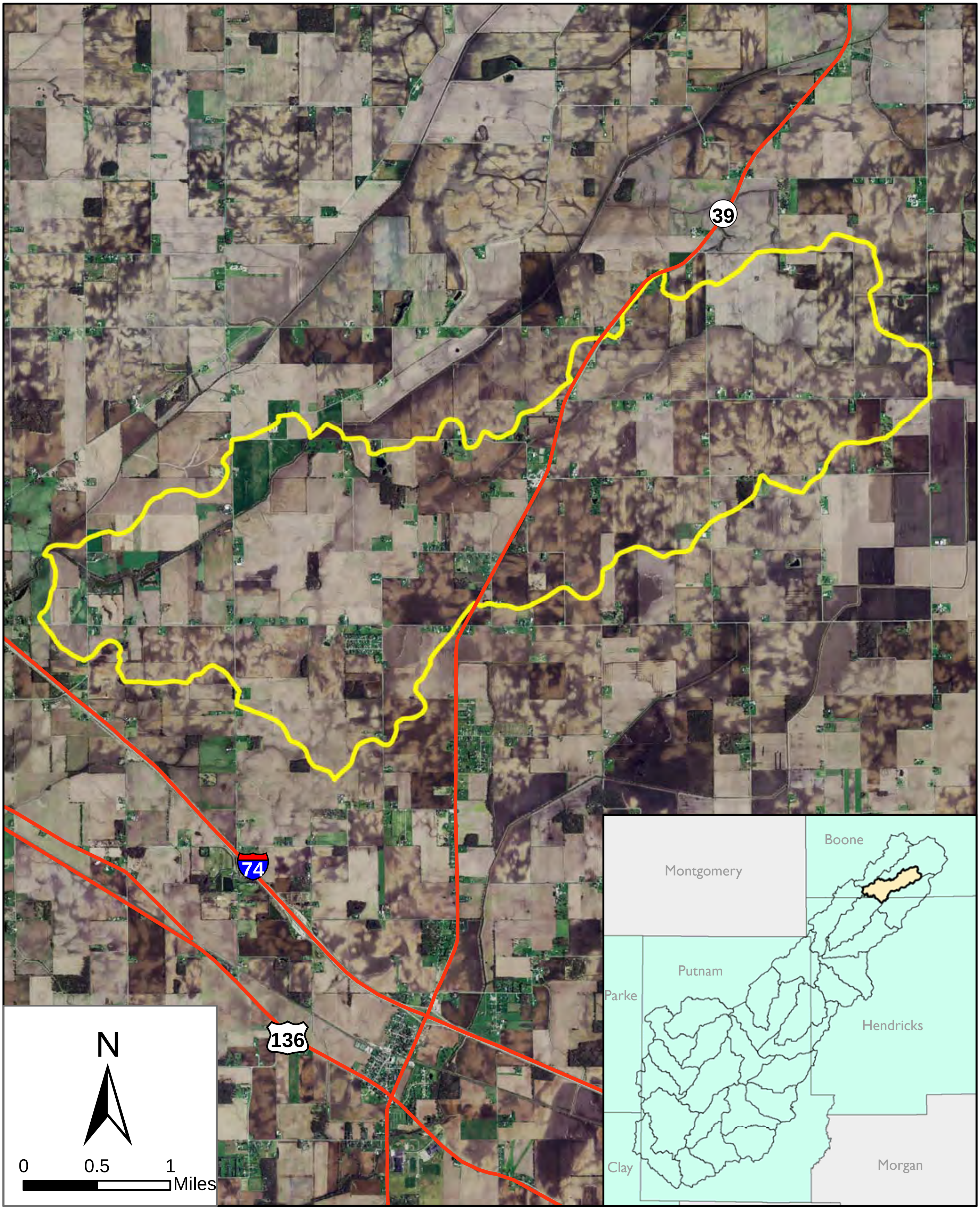



**Figure W15 - Aerial Photography**
**X - Main Edlin Ditch - Grassy Branch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

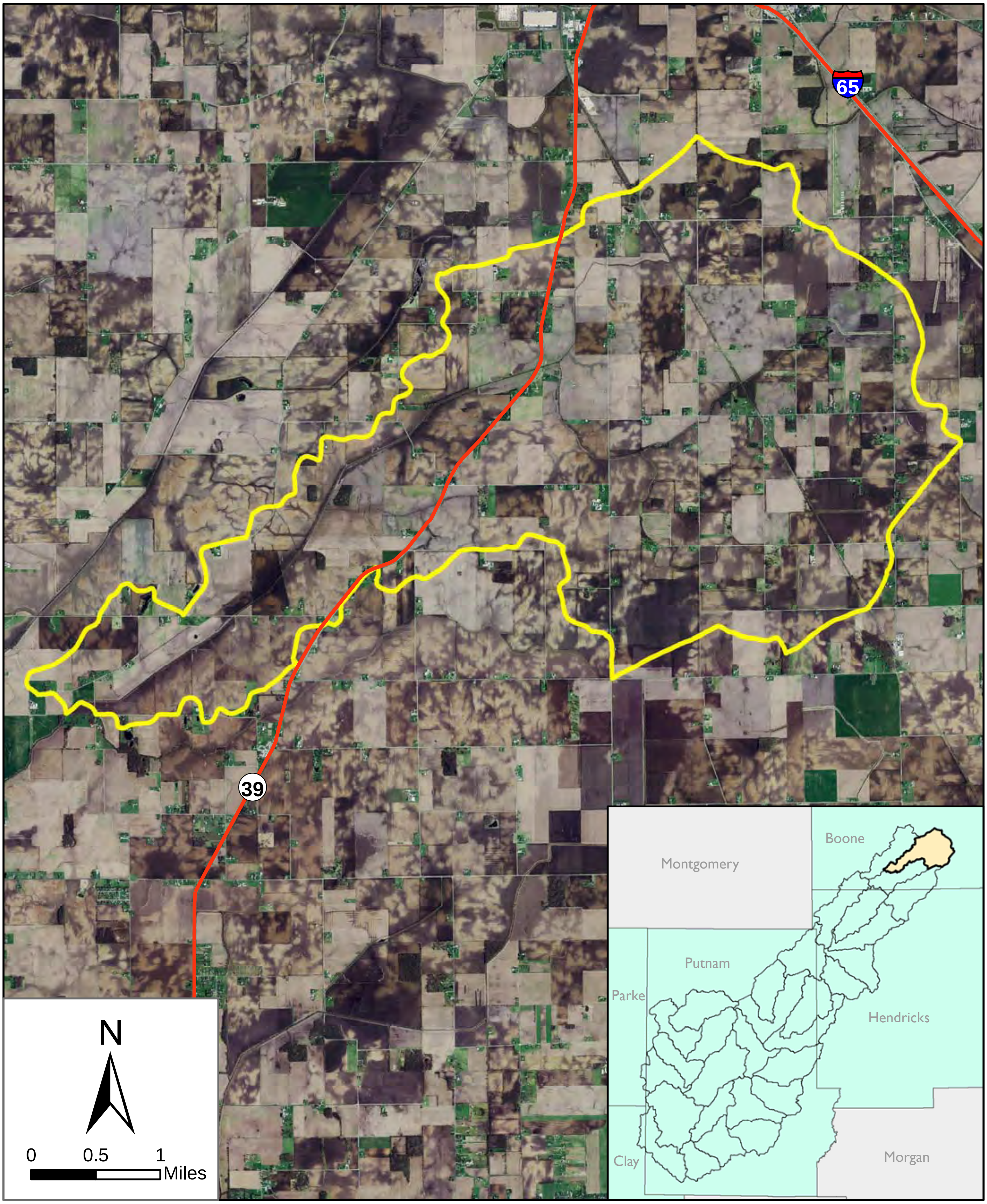



**Figure W16 - Aerial Photography**
**Y - Main Edlin Ditch - Smith Ditch**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

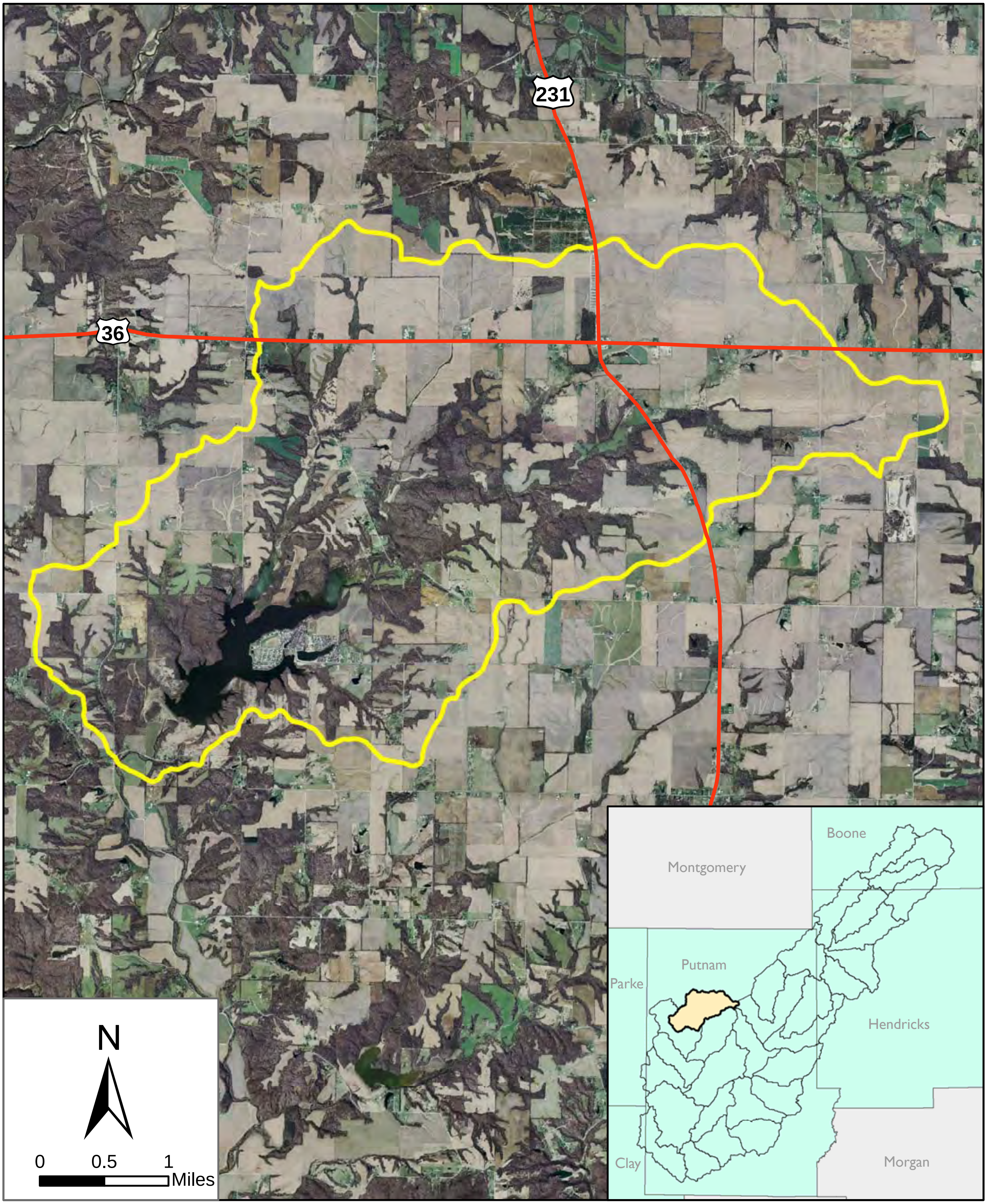



**Figure W17 - Aerial Photography**
**AA - Owl Creek**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

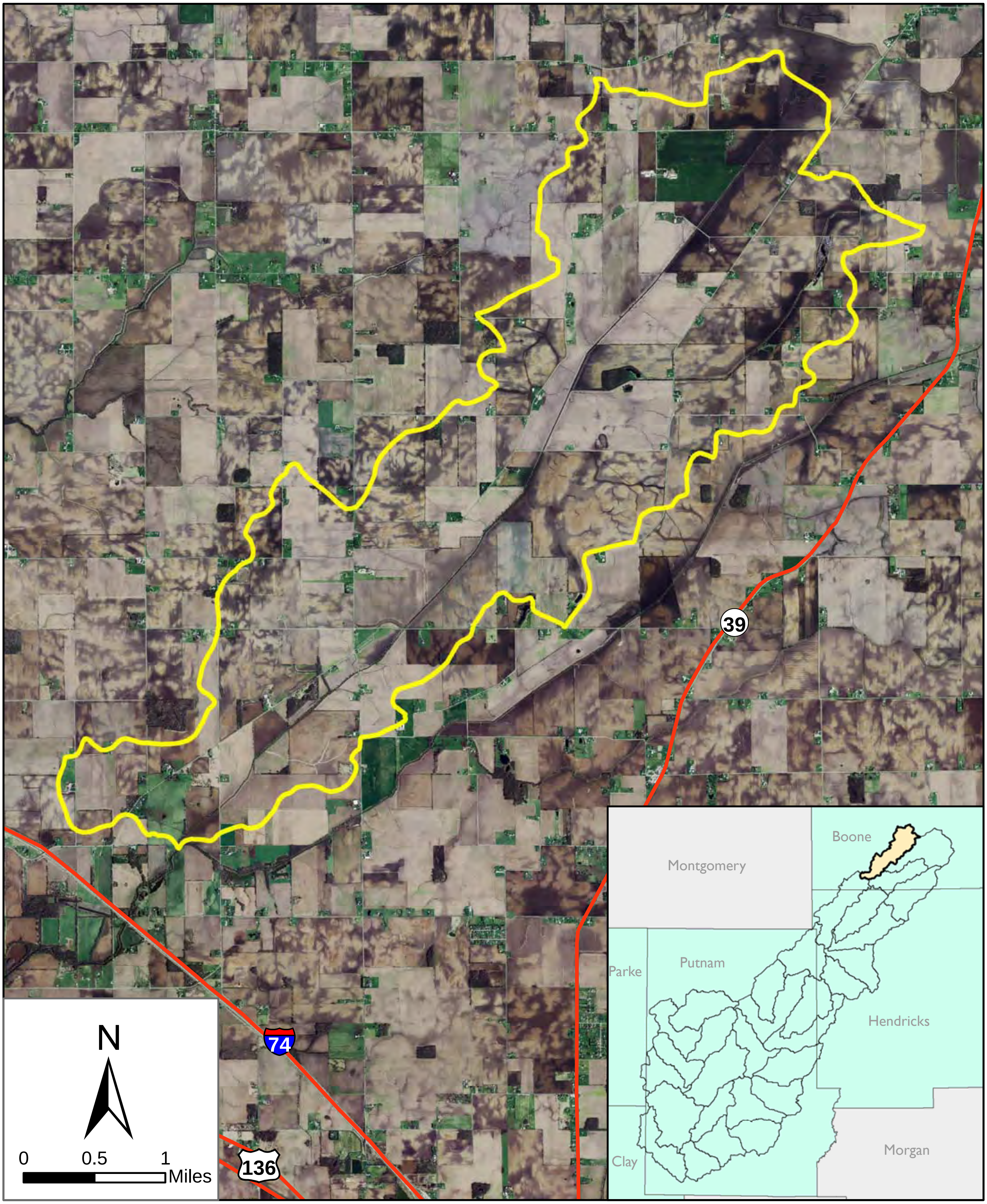



**Figure W18 - Aerial Photography**
**CC - West Fork Big Walnut Creek - Headwaters**
**14-HUC Watershed**

Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

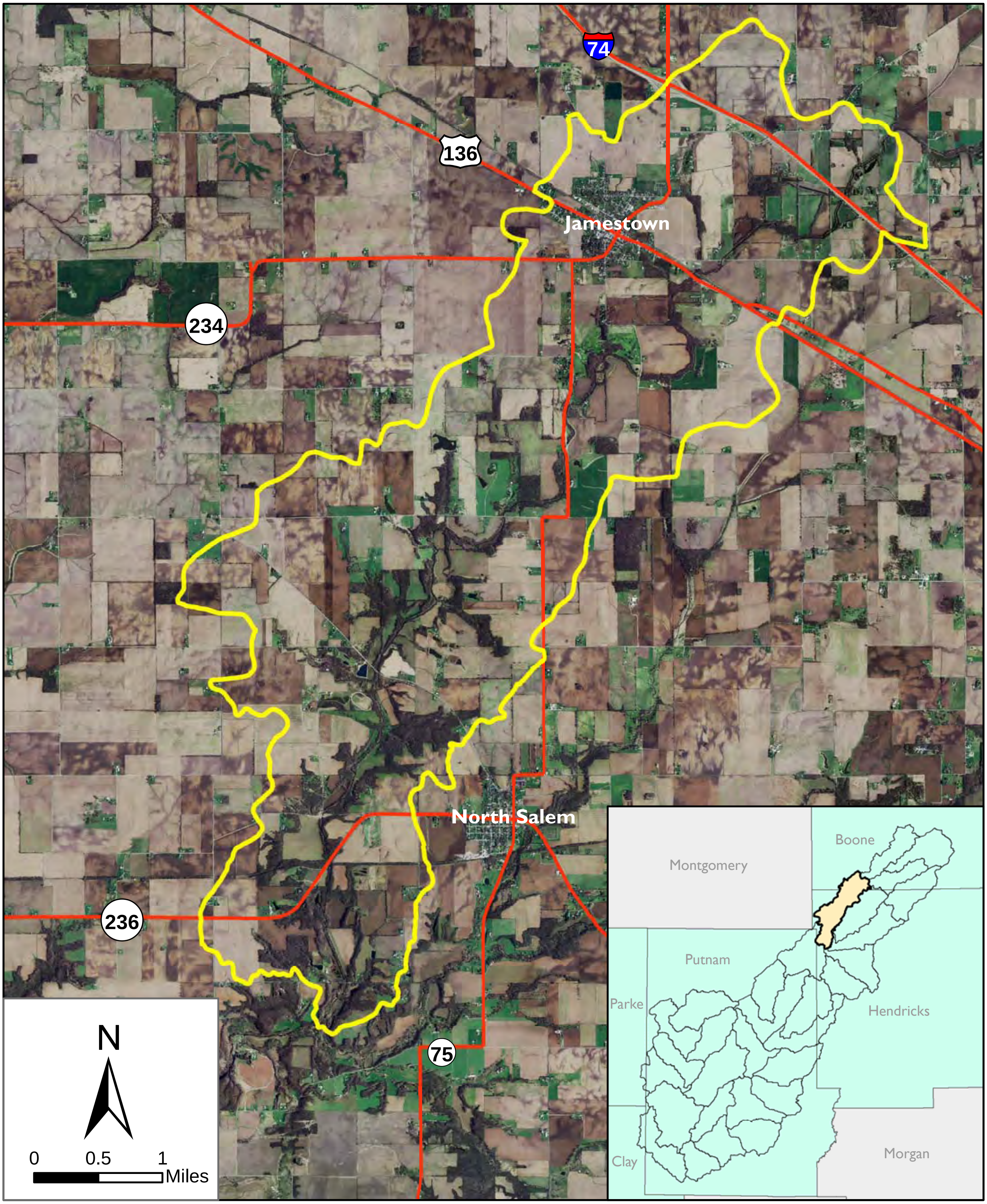



**Figure W19 - Aerial Photography**
**DD - West Fork Big Walnut Creek - Lower**
**14-HUC Watershed**
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

# APPENDIX B
## HISTORICAL CLIMATE DATA

# Historical Climate Data

**Growing Season Summary**
**Station: 129557 WHITESTOWN, IN**

**Growing Degree Day Averages**
**Derived from 1971-2000 Data**

Select a different Station | Select a different County

| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GDD Base 40** | 17 | 38 | 145 | 360 | 689 | 928 | 1075 | 1000 | 772 | 446 | 160 | 36 | 5620 |
| **GDD Base 45** | 7 | 15 | 82 | 238 | 535 | 780 | 920 | 846 | 622 | 307 | 90 | 16 | 4419 |
| **GDD Base 50** | 2 | 5 | 43 | 141 | 387 | 631 | 765 | 692 | 474 | 190 | 44 | 6 | 3349 |
| **GDD Base 55** | 0 | 1 | 19 | 73 | 254 | 484 | 610 | 538 | 332 | 101 | 18 | 2 | 2408 |
| **GDD Base 60** | 0 | 0 | 6 | 31 | 145 | 339 | 456 | 385 | 208 | 45 | 4 | 0 | 1601 |
| **MGDD* Base 50** | 9 | 24 | 94 | 224 | 431 | 617 | 732 | 674 | 500 | 276 | 89 | 18 | 3657 |

*Modified Growing Degree Days: Base 50 Ceiling 86.

**Growing Season Summary**
**Derived from 1971-2000 Averages**

| | Date of Last Spring Occurrence | | | | | Date of First Fall Occurrence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Base Temp °F** | **Median** | **Early** | **90%** | **10%** | **Late** | **Median** | **Early** | **90%** | **10%** | **Late** |
| **32** | 4/26 | 4/05 | 4/13 | 5/08 | 5/17 | 10/10 | 9/21 | 9/23 | 10/26 | 11/04 |
| **30** | 4/18 | 3/24 | 4/06 | 5/04 | 5/09 | 10/15 | 9/23 | 10/01 | 11/03 | 11/04 |
| **28** | 4/11 | 3/23 | 3/27 | 4/25 | 5/07 | 10/23 | 9/22 | 10/06 | 11/09 | 11/22 |
| **24** | 4/05 | 3/14 | 3/19 | 4/16 | 4/24 | 11/07 | 10/14 | 10/21 | 11/23 | 11/29 |
| **20** | 3/19 | 2/25 | 3/11 | 4/07 | 4/10 | 11/15 | 10/21 | 10/31 | 12/06 | 12/22 |
| **16** | 3/13 | 2/15 | 2/23 | 3/27 | 4/07 | 11/30 | 11/02 | 11/09 | 12/18 | 12/24 |

**Length of Growing Season (Days)**
**Derived from 1971-2000 Averages**

| Base Temp °F | Median | Shortest | 10% | 90% | Longest |
|---|---|---|---|---|---|
| **32** | 165 | 138 | 153 | 184 | 201 |
| **30** | 179 | 138 | 163 | 204 | 225 |
| **28** | 194 | 148 | 173 | 219 | 228 |
| **24** | 218 | 192 | 195 | 246 | 255 |
| **20** | 242 | 209 | 216 | 261 | 282 |
| **16** | 259 | 222 | 238 | 284 | 299 |

# Historical Climate Data

**Growing Season Summary**
**Station: 127522 ROCKVILLE, IN**

**Growing Degree Day Averages**
**Derived from 1971-2000 Data**

Select a different Station | Select a different County

| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GDD Base 40** | 24 | 55 | 189 | 419 | 736 | 979 | 1121 | 1054 | 817 | 501 | 195 | 47 | 6075 |
| **GDD Base 45** | 10 | 24 | 112 | 288 | 582 | 830 | 966 | 900 | 668 | 356 | 116 | 22 | 4824 |
| **GDD Base 50** | 3 | 9 | 61 | 178 | 431 | 680 | 812 | 747 | 520 | 229 | 61 | 10 | 3700 |
| **GDD Base 55** | 0 | 3 | 29 | 98 | 289 | 530 | 657 | 593 | 375 | 128 | 27 | 3 | 2705 |
| **GDD Base 60** | 0 | 0 | 11 | 45 | 169 | 383 | 503 | 439 | 244 | 59 | 9 | 0 | 1843 |
| **MGDD* Base 50** | 12 | 33 | 119 | 261 | 469 | 658 | 768 | 720 | 532 | 309 | 107 | 24 | 3972 |

*Modified Growing Degree Days: Base 50 Ceiling 86.

**Growing Season Summary**
**Derived from 1971-2000 Averages**

| | Date of Last Spring Occurrence | | | | | Date of First Fall Occurrence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Base Temp °F** | **Median** | **Early** | **90%** | **10%** | **Late** | **Median** | **Early** | **90%** | **10%** | **Late** |
| **32** | 4/22 | 3/26 | 4/09 | 5/10 | 5/16 | 10/15 | 9/23 | 10/02 | 10/30 | 11/04 |
| **30** | 4/11 | 3/24 | 3/30 | 4/23 | 4/29 | 10/20 | 10/03 | 10/10 | 11/05 | 11/20 |
| **28** | 4/08 | 3/24 | 3/28 | 4/18 | 4/23 | 11/01 | 10/08 | 10/15 | 11/13 | 12/01 |
| **24** | 3/30 | 3/07 | 3/13 | 4/11 | 4/18 | 11/07 | 10/13 | 10/22 | 12/01 | 12/11 |
| **20** | 3/18 | 2/22 | 3/08 | 4/08 | 4/13 | 11/18 | 10/24 | 11/01 | 12/07 | 12/22 |
| **16** | 3/07 | 2/07 | 2/14 | 3/23 | 4/13 | 12/04 | 11/03 | 11/09 | 12/23 | 1/02 |

**Length of Growing Season (Days)**
**Derived from 1971-2000 Averages**

| Base Temp °F | Median | Shortest | 10% | 90% | Longest |
|---|---|---|---|---|---|
| **32** | 176 | 143 | 157 | 195 | 209 |
| **30** | 193 | 173 | 177 | 210 | 224 |
| **28** | 204 | 183 | 188 | 223 | 233 |
| **24** | 226 | 200 | 209 | 251 | 263 |
| **20** | 248 | 214 | 221 | 264 | 284 |
| **16** | 272 | 230 | 246 | 302 | 309 |

# Historical Climate Data

**Growing Season Summary**
**Station: 123513 GREENCASTLE 1 E, IN**

**Growing Degree Day Averages**
**Derived from 1971-2000 Data**

Select a different Station | Select a different County

| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GDD Base 40** | 20 | 45 | 163 | 387 | 714 | 961 | 1101 | 1044 | 811 | 476 | 182 | 38 | 5913 |
| **GDD Base 45** | 7 | 18 | 97 | 262 | 560 | 811 | 946 | 889 | 662 | 336 | 107 | 16 | 4687 |
| **GDD Base 50** | 2 | 6 | 52 | 160 | 411 | 661 | 792 | 734 | 513 | 215 | 57 | 6 | 3591 |
| **GDD Base 55** | 0 | 1 | 24 | 88 | 275 | 512 | 637 | 579 | 370 | 121 | 25 | 1 | 2621 |
| **GDD Base 60** | 0 | 0 | 9 | 42 | 160 | 366 | 482 | 425 | 240 | 57 | 8 | 0 | 1779 |
| **MGDD* Base 50** | 10 | 26 | 100 | 228 | 442 | 646 | 754 | 710 | 522 | 283 | 100 | 21 | 3824 |

*Modified Growing Degree Days: Base 50 Ceiling 86.

**Growing Season Summary**
**Derived from 1971-2000 Averages**

| | Date of Last Spring Occurrence | | | | | Date of First Fall Occurrence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Base Temp °F** | **Median** | **Early** | **90%** | **10%** | **Late** | **Median** | **Early** | **90%** | **10%** | **Late** |
| **32** | 4/21 | 3/25 | 4/07 | 5/05 | 5/09 | 10/20 | 9/22 | 10/06 | 11/04 | 11/20 |
| **30** | 4/14 | 3/24 | 4/02 | 4/29 | 5/07 | 10/24 | 10/03 | 10/11 | 11/11 | 11/20 |
| **28** | 4/09 | 3/24 | 3/28 | 4/16 | 4/23 | 11/03 | 10/10 | 10/14 | 11/17 | 11/25 |
| **24** | 4/01 | 3/13 | 3/17 | 4/10 | 4/19 | 11/08 | 10/21 | 10/30 | 11/23 | 11/30 |
| **20** | 3/18 | 2/18 | 3/05 | 4/06 | 4/09 | 11/20 | 10/24 | 11/06 | 12/08 | 12/22 |
| **16** | 3/08 | 2/08 | 2/15 | 3/25 | 4/07 | 12/05 | 11/03 | 11/14 | 12/20 | 1/02 |

**Length of Growing Season (Days)**
**Derived from 1971-2000 Averages**

| Base Temp °F | Median | Shortest | 10% | 90% | Longest |
|---|---|---|---|---|---|
| **32** | 184 | 148 | 163 | 210 | 224 |
| **30** | 194 | 165 | 176 | 218 | 225 |
| **28** | 207 | 180 | 190 | 226 | 240 |
| **24** | 225 | 195 | 208 | 241 | 256 |
| **20** | 252 | 214 | 225 | 267 | 284 |
| **16** | 271 | 232 | 246 | 301 | 309 |

# Historical Climate Data

### Precipitation Summary
### Station: 129557 WHITESTOWN, IN

### 1971-2000 NCDC Normals

Select a different Station | Select a different County

| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precip (in) | 2.44 | 2.35 | 3.40 | 3.82 | 4.47 | 4.15 | 4.54 | 3.55 | 3.01 | 2.88 | 3.70 | 3.06 | 41.37 |

### Precipitation Extremes
### Period of Record: 1901-2001

| Month | High (in) | Year | Low (in) | Year | 1-Day Max (in) | Date |
|---|---|---|---|---|---|---|
| JAN | 11.49 | 1950 | 0.11 | 1944 | 2.67 | 01-26-1962 |
| FEB | 5.94 | 1990 | 0.30 | 1907 | 2.54 | 02-17-1976 |
| MAR | 9.25 | 1904 | 0.11 | 1910 | 3.20 | 03-25-1904 |
| APR | 11.58 | 1922 | 1.01 | 1915 | 3.09 | 04-06-1948 |
| MAY | 12.74 | 1943 | 0.38 | 1934 | 4.06 | 05-27-1956 |
| JUN | 12.64 | 1957 | 0.14 | 1933 | 7.92 | 06-28-1957 |
| JUL | 14.80 | 1979 | 0.10 | 1901 | 5.29 | 07-08-1915 |
| AUG | 9.84 | 1926 | 0.14 | 1996 | 4.70 | 08-28-1978 |
| SEP | 12.88 | 1926 | 0.17 | 1998 | 4.60 | 09-10-1905 |
| OCT | 7.90 | 2001 | 0.18 | 1963 | 3.60 | 10-26-1920 |
| NOV | 10.13 | 1985 | 0.08 | 1904 | 3.73 | 11-14-1993 |
| DEC | 7.63 | 1990 | 0.28 | 1958 | 2.45 | 12-11-1985 |
| | | | | | | |
| Annual | 55.63 | 1957 | 26.55 | 1910 | 7.92 | 06-28-1957 |
| Winter | 19.41 | 1950 | 2.52 | 1963 | 2.67 | 01-26-1962 |
| Spring | 21.89 | 1922 | 4.74 | 1932 | 4.06 | 05-27-1956 |
| Summer | 23.48 | 1958 | 3.35 | 1991 | 7.92 | 06-28-1957 |
| Fall | 18.76 | 1926 | 2.19 | 1963 | 4.60 | 09-10-1905 |

**Precipitation Threshold Climatology**
**Derived from 1971-2000 Averages**

*Annual/seasonal totals may differ from the sum of the monthly totals due to rounding.

| Month | # Days Total ≥ 0.01" | # Days Total ≥ 0.10" | # Days Total ≥ 0.50" | # Days Total ≥ 1.00" |
|---|---|---|---|---|
| JAN | 11.2 | 5.7 | 1.4 | 0.2 |
| FEB | 9.2 | 5.3 | 1.4 | 0.4 |
| MAR | 11.5 | 7.5 | 2.4 | 0.5 |
| APR | 12.5 | 8.6 | 2.5 | 0.7 |
| MAY | 11.6 | 9.0 | 3.1 | 0.9 |
| JUN | 9.7 | 6.9 | 2.8 | 1.1 |
| JUL | 9.5 | 6.9 | 3.1 | 1.0 |
| AUG | 8.2 | 5.8 | 2.6 | 1.0 |
| SEP | 8.1 | 5.6 | 2.3 | 0.7 |
| OCT | 8.4 | 5.3 | 2.1 | 0.6 |
| NOV | 10.4 | 6.7 | 2.2 | 1.1 |
| DEC | 12.3 | 6.8 | 1.8 | 0.4 |
| | | | | |
| Annual | 122.6 | 80.1 | 27.6 | 8.8 |
| Winter | 32.7 | 17.8 | 4.6 | 1.0 |
| Spring | 35.7 | 25.1 | 8.0 | 2.1 |
| Summer | 27.3 | 19.6 | 8.5 | 3.2 |
| Fall | 26.9 | 17.5 | 6.6 | 2.5 |

# Historical Climate Data

### Precipitation Summary
### Station: 120877 BOWLING GREEN 3 NE, IN

### 1971-2000 NCDC Normals

Select a different Station | Select a different County

| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precip (in) | 2.48 | 2.52 | 3.69 | 4.12 | 4.71 | 4.60 | 4.83 | 4.29 | 3.36 | 2.83 | 3.95 | 3.07 | 44.45 |

### Precipitation Extremes
### Period of Record: 1948-2001

| Month | High (in) | Year | Low (in) | Year | 1-Day Max (in) | Date |
|---|---|---|---|---|---|---|
| JAN | 9.99 | 1950 | 0.11 | 1986 | 3.20 | 01-22-1999 |
| FEB | 6.27 | 1971 | 0.48 | 1978 | 2.96 | 02-10-1965 |
| MAR | 8.35 | 1963 | 0.48 | 2001 | 3.33 | 03-31-1992 |
| APR | 7.83 | 1996 | 1.12 | 1976 | 2.85 | 04-29-1996 |
| MAY | 12.12 | 1981 | 1.39 | 1987 | 3.07 | 05-01-1962 |
| JUN | 11.28 | 1998 | 0.44 | 1988 | 4.12 | 06-24-1984 |
| JUL | 11.95 | 1987 | 0.98 | 1983 | 6.80 | 07-21-1973 |
| AUG | 10.30 | 1985 | 0.85 | 1969 | 4.62 | 08-04-1975 |
| SEP | 7.35 | 2000 | 0.22 | 1963 | 3.53 | 09-01-1950 |
| OCT | 9.35 | 2001 | 0.23 | 1952 | 2.95 | 10-07-1998 |
| NOV | 11.50 | 1985 | 0.45 | 1999 | 4.00 | 11-16-1955 |
| DEC | 8.34 | 1957 | 0.36 | 1955 | 2.90 | 12-30-1990 |
| | | | | | | |
| Annual | 55.51 | 1985 | 27.84 | 1988 | 6.80 | 07-21-1973 |
| Winter | 14.70 | 1949 | 3.21 | 1981 | 3.20 | 01-22-1999 |
| Spring | 20.59 | 1981 | 7.16 | 1954 | 3.33 | 03-31-1992 |
| Summer | 22.19 | 1973 | 5.62 | 1988 | 6.80 | 07-21-1973 |
| Fall | 19.22 | 1993 | 2.73 | 1999 | 4.00 | 11-16-1955 |

**Precipitation Threshold Climatology**
**Derived from 1971-2000 Averages**

*Annual/seasonal totals may differ from the sum of the monthly totals due to rounding.

| Month | # Days Total ≥ 0.01" | # Days Total ≥ 0.10" | # Days Total ≥ 0.50" | # Days Total ≥ 1.00" |
|---|---|---|---|---|
| JAN | 8.6 | 5.9 | 1.6 | 0.5 |
| FEB | 7.5 | 5.3 | 1.5 | 0.5 |
| MAR | 9.0 | 7.3 | 2.6 | 0.9 |
| APR | 9.7 | 8.1 | 2.9 | 1.0 |
| MAY | 8.9 | 7.7 | 3.5 | 1.3 |
| JUN | 7.9 | 7.2 | 3.4 | 1.6 |
| JUL | 7.4 | 6.5 | 3.4 | 1.6 |
| AUG | 6.7 | 5.8 | 3.3 | 1.3 |
| SEP | 5.8 | 5.2 | 2.6 | 1.0 |
| OCT | 5.8 | 4.7 | 2.1 | 0.8 |
| NOV | 7.3 | 6.5 | 2.9 | 1.2 |
| DEC | 8.1 | 6.2 | 2.2 | 0.7 |
| | | | | |
| Annual | 92.6 | 76.4 | 32.2 | 12.4 |
| Winter | 24.2 | 17.4 | 5.4 | 1.6 |
| Spring | 27.6 | 23.2 | 9.1 | 3.2 |
| Summer | 22.0 | 19.4 | 10.1 | 4.5 |
| Fall | 18.9 | 16.4 | 7.6 | 3.0 |

# Historical Climate Data

**Precipitation Summary**
**Station: 127522 ROCKVILLE, IN**

**1971-2000 NCDC Normals**

Select a different Station | Select a different County

| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precip (in) | 2.54 | 2.25 | 3.71 | 4.10 | 4.78 | 4.25 | 4.89 | 4.47 | 3.08 | 3.05 | 4.26 | 3.52 | 44.90 |

**Precipitation Extremes**
**Period of Record: 1901-2001**

| Month | High (in) | Year | Low (in) | Year | 1-Day Max (in) | Date |
|---|---|---|---|---|---|---|
| JAN | 10.94 | 1950 | 0.03 | 1986 | 2.91 | 01-03-1950 |
| FEB | 6.27 | 1985 | 0.14 | 1947 | 2.34 | 02-13-1946 |
| MAR | 9.07 | 1922 | 0.01 | 1910 | 3.70 | 03-14-1922 |
| APR | 8.73 | 1964 | 1.14 | 1971 | 2.34 | 04-02-1918 |
| MAY | 13.41 | 1943 | 0.25 | 1979 | 8.05 | 05-26-1989 |
| JUN | 13.15 | 1957 | 0.20 | 1933 | 8.74 | 06-28-1957 |
| JUL | 11.01 | 1910 | 0.26 | 1974 | 4.30 | 07-28-1979 |
| AUG | 10.46 | 1993 | 0.60 | 1953 | 4.73 | 08-12-1993 |
| SEP | 9.07 | 1926 | 0.24 | 1963 | 4.75 | 09-09-1989 |
| OCT | 10.44 | 1919 | 0.21 | 1908 | 3.78 | 10-18-1917 |
| NOV | 14.00 | 1985 | 0.21 | 1917 | 4.15 | 11-12-1992 |
| DEC | 11.19 | 1967 | 0.40 | 1919 | 5.52 | 12-21-1967 |
| | | | | | | |
| Annual | 61.91 | 1993 | 28.17 | 1980 | 8.74 | 06-28-1957 |
| Winter | 20.22 | 1950 | 1.91 | 1963 | 5.52 | 12-21-1967 |
| Spring | 20.98 | 1996 | 4.82 | 1932 | 8.05 | 05-26-1989 |
| Summer | 21.92 | 1958 | 3.60 | 1988 | 8.74 | 06-28-1957 |
| Fall | 19.49 | 1992 | 3.18 | 1953 | 4.75 | 09-09-1989 |

**Precipitation Threshold Climatology**
**Derived from 1971-2000 Averages**

*Annual/seasonal totals may differ from the sum of the monthly totals due to rounding.

| Month | # Days Total ≥ 0.01" | # Days Total ≥ 0.10" | # Days Total ≥ 0.50" | # Days Total ≥ 1.00" |
|---|---|---|---|---|
| JAN | 7.5 | 5.9 | 1.8 | 0.5 |
| FEB | 6.2 | 5.1 | 1.5 | 0.6 |
| MAR | 8.3 | 6.7 | 3.0 | 0.8 |
| APR | 9.8 | 8.2 | 3.2 | 1.1 |
| MAY | 9.5 | 8.0 | 3.3 | 1.3 |
| JUN | 8.9 | 7.3 | 3.2 | 1.3 |
| JUL | 7.5 | 6.3 | 3.4 | 1.8 |
| AUG | 7.6 | 6.2 | 2.9 | 1.4 |
| SEP | 6.2 | 5.0 | 2.3 | 1.0 |
| OCT | 7.1 | 5.4 | 2.2 | 0.9 |
| NOV | 8.3 | 7.0 | 2.8 | 1.2 |
| DEC | 8.1 | 6.6 | 2.5 | 0.9 |
| | | | | |
| Annual | 95.2 | 78.0 | 32.3 | 12.8 |
| Winter | 21.9 | 17.7 | 5.9 | 2.0 |
| Spring | 27.5 | 22.9 | 9.5 | 3.1 |
| Summer | 24.0 | 19.8 | 9.4 | 4.5 |
| Fall | 21.7 | 17.5 | 7.4 | 3.1 |

# Historical Climate Data

**Precipitation Summary**
**Station: 123513 GREENCASTLE 1 E, IN**

**1971-2000 NCDC Normals**

Select a different Station | Select a different County

| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precip (in) | 2.40 | 2.52 | 3.62 | 3.82 | 4.75 | 4.32 | 5.14 | 4.22 | 3.25 | 3.12 | 3.96 | 3.08 | 44.20 |

**Precipitation Extremes**
**Period of Record: 1896-2001**

| Month | High (in) | Year | Low (in) | Year | 1-Day Max (in) | Date |
|---|---|---|---|---|---|---|
| JAN | 13.68 | 1950 | 0.22 | 1986 | 4.56 | 01-04-1950 |
| FEB | 6.21 | 1971 | 0.19 | 1947 | 3.10 | 02-27-1997 |
| MAR | 10.62 | 1898 | 0.44 | 2001 | 3.71 | 03-04-1897 |
| APR | 11.37 | 1922 | 0.03 | 1899 | 3.40 | 04-11-1922 |
| MAY | 11.56 | 1943 | 0.90 | 1988 | 3.95 | 05-24-1968 |
| JUN | 14.32 | 1941 | 0.05 | 1988 | 6.50 | 06-22-1952 |
| JUL | 11.80 | 1979 | 0.00 | 1901 | 4.63 | 07-14-1962 |
| AUG | 11.22 | 1979 | 0.83 | 1955 | 5.12 | 08-19-1934 |
| SEP | 14.32 | 1950 | 0.14 | 1963 | 6.35 | 09-01-1950 |
| OCT | 9.39 | 1986 | 0.16 | 1963 | 4.30 | 10-26-1991 |
| NOV | 10.77 | 1985 | 0.15 | 1904 | 2.80 | 11-02-1972 |
| DEC | 7.92 | 1990 | 0.02 | 1919 | 2.85 | 12-30-1990 |
| | | | | | | |
| Annual | 61.45 | 1950 | 22.10 | 1899 | 6.50 | 06-22-1952 |
| Winter | 21.73 | 1950 | 2.10 | 1944 | 4.56 | 01-04-1950 |
| Spring | 25.42 | 1922 | 5.55 | 1932 | 3.95 | 05-24-1968 |
| Summer | 28.58 | 1979 | 3.80 | 1933 | 6.50 | 06-22-1952 |
| Fall | 21.14 | 1950 | 2.75 | 1963 | 6.35 | 09-01-1950 |

**Precipitation Threshold Climatology**
**Derived from 1971-2000 Averages**

*Annual/seasonal totals may differ from the sum of the monthly totals due to rounding.

| Month | # Days Total ≥ 0.01" | # Days Total ≥ 0.10" | # Days Total ≥ 0.50" | # Days Total ≥ 1.00" |
|---|---|---|---|---|
| JAN | 10.5 | 6.1 | 1.5 | 0.3 |
| FEB | 8.8 | 5.5 | 1.7 | 0.4 |
| MAR | 11.0 | 7.1 | 2.6 | 0.9 |
| APR | 11.3 | 7.8 | 2.7 | 0.7 |
| MAY | 10.9 | 8.4 | 3.8 | 1.4 |
| JUN | 10.0 | 7.7 | 3.3 | 1.0 |
| JUL | 9.4 | 7.2 | 3.4 | 1.7 |
| AUG | 8.7 | 6.2 | 3.1 | 1.3 |
| SEP | 7.1 | 5.0 | 2.4 | 1.0 |
| OCT | 8.2 | 5.3 | 1.8 | 0.8 |
| NOV | 10.1 | 6.8 | 2.7 | 1.2 |
| DEC | 11.3 | 6.5 | 2.1 | 0.6 |
| | | | | |
| Annual | 117.3 | 79.6 | 31.0 | 11.2 |
| Winter | 30.6 | 18.1 | 5.3 | 1.3 |
| Spring | 33.1 | 23.4 | 9.0 | 2.9 |
| Summer | 28.1 | 21.1 | 9.8 | 4.0 |
| Fall | 25.5 | 17.1 | 6.8 | 3.0 |

# Historical Climate Data

### Temperature Summary
### Station: 129557 WHITESTOWN, IN

### 1971-2000 NCDC Normals

Select a different Station    Select a different County

| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max °F | 34.3 | 40.4 | 51.8 | 64.5 | 75.0 | 83.5 | 86.4 | 84.7 | 78.7 | 66.7 | 51.9 | 38.8 | 63.1 |
| Min °F | 17.6 | 21.7 | 30.8 | 40.0 | 50.3 | 59.5 | 63.0 | 60.8 | 53.2 | 42.8 | 34.1 | 23.4 | 41.4 |
| Mean °F | 26.0 | 31.1 | 41.3 | 52.3 | 62.7 | 71.5 | 74.7 | 72.8 | 66.0 | 54.8 | 43.0 | 31.1 | 52.3 |
| HDD base 65 | 1211 | 951 | 734 | 386 | 167 | 16 | 1 | 12 | 69 | 334 | 660 | 1050 | 5591 |
| CDD base 65 | 0 | 0 | 0 | 3 | 94 | 211 | 301 | 253 | 97 | 16 | 0 | 0 | 975 |

### Temperature Extremes
### Period of Record: 1901-2001

| Month | High Mean°F | Year | Low Mean°F | Year | 1-Day Max°F | Date | 1-Day Min°F | Date |
|---|---|---|---|---|---|---|---|---|
| JAN | 37.4 | 1933 | 8.1 | 1977 | 70 | 01-25-1950 | -27 | 01-19-1994 |
| FEB | 39.7 | 1998 | 12.7 | 1978 | 74 | 02-25-2000 | -22 | 02-13-1905 |
| MAR | 51.1 | 1946 | 25.2 | 1960 | 84 | 03-24-1910 | -12 | 03-12-1948 |
| APR | 59.0 | 2001 | 40.7 | 1907 | 91 | 04-23-1925 | 15 | 04-12-1940 |
| MAY | 69.6 | 1991 | 53.9 | 1907 | 99 | 05-31-1934 | 24 | 05-09-1947 |
| JUN | 78.7 | 1934 | 63.9 | 1903 | 104 | 06-28-1934 | 35 | 06-03-1910 |
| JUL | 82.7 | 1936 | 68.9 | 1947 | 112 | 07-14-1936 | 43 | 07-02-1904 |
| AUG | 80.0 | 1936 | 67.0 | 1915 | 106 | 08-22-1936 | 37 | 08-29-1986 |
| SEP | 73.1 | 1925 | 58.5 | 1949 | 105 | 09-15-1939 | 24 | 09-28-1942 |
| OCT | 61.8 | 1963 | 45.9 | 1925 | 90 | 10-08-1939 | 13 | 10-31-1908 |
| NOV | 50.5 | 2001 | 33.7 | 1976 | 80 | 11-01-1933 | -6 | 11-28-1930 |
| DEC | 40.6 | 1923 | 17.9 | 1983 | 73 | 12-03-1982 | -23 | 12-28-1924 |
| | | | | | | | | |
| Annual | 55.8 | 1998 | 46.8 | 1910 | 112 | 07-14-1936 | -27 | 01-19-1994 |
| Winter | 36.7 | 1932 | 17.6 | 1978 | 74 | 02-25-1900 | -27 | 01-19-1994 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Spring** | 56.7 | 1991 | 45.8 | 1984 | 99 | 05-31-1934 | -12 | 03-12-1948 |
| **Summer** | 78.3 | 1936 | 68.3 | 1904 | 112 | 07-14-1936 | 35 | 06-03-1910 |
| **Fall** | 58.4 | 1931 | 47.8 | 1976 | 105 | 09-15-1939 | -6 | 11-28-1930 |

## Temperature Threshold Climatology
## Derived from 1971-2000 Averages

*Annual/seasonal totals may differ from the sum of the monthly totals due to rounding.

| **Month** | **# Days Max ≥ 90°F** | **# Days Max ≤ 32°F** | **# Days Min ≤ 32°F** | **# Days Min ≤ 0°F** |
|---|---|---|---|---|
| **JAN** | 0.0 | 14.2 | 27.9 | 5.4 |
| **FEB** | 0.0 | 8.6 | 23.6 | 3.7 |
| **MAR** | 0.0 | 2.4 | 19.6 | 0.4 |
| **APR** | 0.0 | 0.0 | 7.6 | 0.0 |
| **MAY** | 0.7 | 0.0 | 0.5 | 0.0 |
| **JUN** | 4.7 | 0.0 | 0.0 | 0.0 |
| **JUL** | 8.1 | 0.0 | 0.0 | 0.0 |
| **AUG** | 5.1 | 0.0 | 0.0 | 0.0 |
| **SEP** | 2.2 | 0.0 | 0.2 | 0.0 |
| **OCT** | 0.0 | 0.0 | 5.6 | 0.0 |
| **NOV** | 0.0 | 1.1 | 15.9 | 0.0 |
| **DEC** | 0.0 | 8.2 | 25.0 | 2.0 |
| | | | | |
| **Annual** | 20.6 | 34.6 | 126.5 | 11.5 |
| **Winter** | 0.0 | 31.0 | 76.5 | 11.1 |
| **Spring** | 0.7 | 2.4 | 27.7 | 0.4 |
| **Summer** | 17.9 | 0.0 | 0.0 | 0.0 |
| **Fall** | 2.3 | 1.1 | 21.7 | 0.0 |

# Historical Climate Data

### Temperature Summary
### Station: 127522 ROCKVILLE, IN

### 1971-2000 NCDC Normals

Select a different Station    Select a different County

| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Max °F** | 35.7 | 41.9 | 53.5 | 65.6 | 75.8 | 84.3 | 87.2 | 85.0 | 79.0 | 67.7 | 53.1 | 40.3 | 64.1 |
| **Min °F** | 19.4 | 24.1 | 33.4 | 43.0 | 52.4 | 61.2 | 65.2 | 63.3 | 55.7 | 44.7 | 35.7 | 25.0 | 43.6 |
| **Mean °F** | 27.6 | 33.0 | 43.5 | 54.3 | 64.1 | 72.8 | 76.2 | 74.2 | 67.4 | 56.2 | 44.4 | 32.7 | 53.9 |
| **HDD base 65** | 1161 | 897 | 668 | 331 | 134 | 9 | 0 | 5 | 47 | 294 | 617 | 1003 | 5166 |
| **CDD base 65** | 0 | 0 | 0 | 9 | 106 | 243 | 348 | 289 | 118 | 21 | 0 | 0 | 1134 |

### Temperature Extremes
### Period of Record: 1901-2001

| Month | High Mean°F | Year | Low Mean°F | Year | 1-Day Max°F | Date | 1-Day Min°F | Date |
|---|---|---|---|---|---|---|---|---|
| **JAN** | 38.6 | 1933 | 12.4 | 1977 | 70 | 01-25-1950 | -25 | 01-19-1994 |
| **FEB** | 41.5 | 1998 | 18.2 | 1979 | 74 | 02-25-2000 | -22 | 02-13-1905 |
| **MAR** | 53.2 | 1946 | 27.5 | 1960 | 89 | 03-27-1967 | -9 | 03-08-1943 |
| **APR** | 60.3 | 1977 | 43.6 | 1907 | 92 | 04-11-1930 | 15 | 04-14-1979 |
| **MAY** | 71.2 | 1977 | 55.5 | 1910 | 96 | 05-31-1934 | 27 | 05-10-1966 |
| **JUN** | 78.9 | 1934 | 65.4 | 1903 | 103 | 06-20-1953 | 37 | 06-16-1917 |
| **JUL** | 83.1 | 1936 | 71.8 | 1909 | 109 | 07-14-1936 | 44 | 07-05-1964 |
| **AUG** | 80.5 | 1936 | 67.0 | 1915 | 106 | 08-05-1918 | 39 | 08-31-1915 |
| **SEP** | 73.8 | 1925 | 59.6 | 1918 | 103 | 09-05-1954 | 25 | 09-28-1942 |
| **OCT** | 63.6 | 1963 | 46.9 | 1925 | 92 | 10-04-1922 | 18 | 10-29-1925 |
| **NOV** | 51.6 | 1931 | 35.8 | 1911 | 82 | 11-01-1950 | -5 | 11-24-1950 |
| **DEC** | 40.9 | 1923 | 19.7 | 1989 | 74 | 12-02-1982 | -22 | 12-28-1924 |
| | | | | | | | | |
| **Annual** | 56.8 | 1998 | 46.1 | 1979 | 109 | 07-14-1936 | -25 | 01-19-1994 |
| **Winter** | 39.2 | 1932 | 21.1 | 1979 | 74 | 12-02-1982 | -25 | 01-19-1994 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Spring** | 59.7 | 1977 | 47.9 | 1912 | 96 | 05-31-1934 | -9 | 03-08-1943 |
| **Summer** | 79.0 | 1936 | 69.7 | 1915 | 109 | 07-14-1936 | 37 | 06-16-1917 |
| **Fall** | 61.1 | 1931 | 50.5 | 1976 | 103 | 09-05-1954 | -5 | 11-24-1950 |

## Temperature Threshold Climatology
## Derived from 1971-2000 Averages

*Annual/seasonal totals may differ from the sum of the monthly totals due to rounding.

| **Month** | **# Days Max ≥ 90°F** | **# Days Max ≤ 32°F** | **# Days Min ≤ 32°F** | **# Days Min ≤ 0°F** |
|---|---|---|---|---|
| **JAN** | 0.0 | 12.4 | 26.8 | 3.9 |
| **FEB** | 0.0 | 6.8 | 22.1 | 2.4 |
| **MAR** | 0.0 | 1.3 | 16.6 | 0.1 |
| **APR** | 0.0 | 0.0 | 5.8 | 0.0 |
| **MAY** | 0.9 | 0.0 | 0.3 | 0.0 |
| **JUN** | 6.6 | 0.0 | 0.0 | 0.0 |
| **JUL** | 10.5 | 0.0 | 0.0 | 0.0 |
| **AUG** | 6.6 | 0.0 | 0.0 | 0.0 |
| **SEP** | 2.6 | 0.0 | 0.1 | 0.0 |
| **OCT** | 0.0 | 0.0 | 3.7 | 0.0 |
| **NOV** | 0.0 | 0.7 | 13.8 | 0.0 |
| **DEC** | 0.0 | 6.8 | 23.9 | 1.5 |
| | | | | |
| **Annual** | 27.1 | 28.1 | 113.6 | 7.9 |
| **Winter** | 0.0 | 26.0 | 72.8 | 7.8 |
| **Spring** | 0.9 | 1.3 | 22.7 | 0.1 |
| **Summer** | 23.7 | 0.0 | 0.0 | 0.0 |
| **Fall** | 2.5 | 0.7 | 17.5 | 0.0 |

# Historical Climate Data

**Temperature Summary**
**Station: 123513 GREENCASTLE 1 E, IN**

**1971-2000 NCDC Normals**

Select a different Station    Select a different County

| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max °F | 34.0 | 39.9 | 50.9 | 62.9 | 73.8 | 82.4 | 86.0 | 84.3 | 78.1 | 65.9 | 51.6 | 38.9 | 62.4 |
| Min °F | 17.7 | 22.0 | 31.5 | 41.7 | 52.2 | 61.4 | 64.9 | 63.2 | 55.8 | 44.3 | 34.2 | 23.1 | 42.7 |
| Mean °F | 25.9 | 31.0 | 41.2 | 52.3 | 63.0 | 71.9 | 75.5 | 73.8 | 67.0 | 55.1 | 42.9 | 31.0 | 52.6 |
| HDD base 65 | 1214 | 953 | 738 | 386 | 157 | 13 | 1 | 10 | 64 | 325 | 663 | 1055 | 5579 |
| CDD base 65 | 0 | 0 | 0 | 5 | 94 | 221 | 325 | 280 | 122 | 19 | 0 | 0 | 1066 |

**Temperature Extremes**
**Period of Record: 1896-2001**

| Month | High Mean°F | Year | Low Mean°F | Year | 1-Day Max°F | Date | 1-Day Min°F | Date |
|---|---|---|---|---|---|---|---|---|
| JAN | 39.5 | 1933 | 10.9 | 1977 | 71 | 01-26-1950 | -23 | 01-20-1985 |
| FEB | 41.6 | 1930 | 18.0 | 1978 | 74 | 02-10-1932 | -20 | 02-02-1951 |
| MAR | 54.3 | 1946 | 26.0 | 1960 | 86 | 03-24-1929 | -8 | 03-08-1943 |
| APR | 59.0 | 1925 | 46.3 | 1904 | 90 | 04-23-1925 | 16 | 04-07-1982 |
| MAY | 70.7 | 1977 | 56.9 | 1924 | 94 | 05-24-1921 | 28 | 05-09-1947 |
| JUN | 77.3 | 1921 | 66.0 | 1903 | 105 | 06-27-1954 | 37 | 06-22-1992 |
| JUL | 82.0 | 1936 | 70.6 | 2000 | 108 | 07-08-1936 | 41 | 07-20-1929 |
| AUG | 80.1 | 1947 | 69.1 | 1992 | 102 | 08-04-1930 | 40 | 08-29-1965 |
| SEP | 74.6 | 1925 | 61.9 | 1993 | 106 | 09-06-1954 | 26 | 09-26-1928 |
| OCT | 63.8 | 1947 | 47.8 | 1925 | 93 | 10-04-1953 | 18 | 10-29-1925 |
| NOV | 51.1 | 1931 | 34.5 | 1951 | 85 | 11-01-1950 | -6 | 11-25-1950 |
| DEC | 41.5 | 1923 | 17.4 | 2000 | 74 | 12-03-1982 | -21 | 12-22-1989 |
| | | | | | | | | |
| Annual | 58.4 | 1944 | 47.2 | 1905 | 108 | 07-08-1936 | -23 | 01-20-1985 |
| Winter | 39.4 | 1932 | 20.9 | 1978 | 74 | 12-03-1982 | -23 | 01-20-1985 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Spring** | 58.6 | 1977 | 46.5 | 1984 | 94 | 05-24-1921 | -8 | 03-08-1943 |
| **Summer** | 77.8 | 1936 | 70.1 | 1992 | 108 | 07-08-1936 | 37 | 06-22-1992 |
| **Fall** | 61.2 | 1927 | 49.9 | 1976 | 106 | 09-06-1954 | -6 | 11-25-1950 |

## Temperature Threshold Climatology
## Derived from 1971-2000 Averages

*Annual/seasonal totals may differ from the sum of the monthly totals due to rounding.

| Month | # Days Max ≥ 90°F | # Days Max ≤ 32°F | # Days Min ≤ 32°F | # Days Min ≤ 0°F |
|---|---|---|---|---|
| **JAN** | 0.0 | 14.1 | 27.7 | 3.9 |
| **FEB** | 0.0 | 8.1 | 22.5 | 2.2 |
| **MAR** | 0.0 | 2.5 | 17.8 | 0.1 |
| **APR** | 0.0 | 0.0 | 5.5 | 0.0 |
| **MAY** | 0.9 | 0.0 | 0.3 | 0.0 |
| **JUN** | 5.0 | 0.0 | 0.0 | 0.0 |
| **JUL** | 9.5 | 0.0 | 0.0 | 0.0 |
| **AUG** | 6.1 | 0.0 | 0.0 | 0.0 |
| **SEP** | 2.6 | 0.0 | 0.1 | 0.0 |
| **OCT** | 0.1 | 0.0 | 3.2 | 0.0 |
| **NOV** | 0.0 | 1.2 | 14.7 | 0.0 |
| **DEC** | 0.0 | 8.4 | 25.2 | 1.9 |
| | | | | |
| **Annual** | 24.2 | 34.3 | 117.1 | 8.0 |
| **Winter** | 0.0 | 30.6 | 75.4 | 7.9 |
| **Spring** | 1.0 | 2.5 | 23.5 | 0.1 |
| **Summer** | 20.7 | 0.0 | 0.0 | 0.0 |
| **Fall** | 2.6 | 1.2 | 18.0 | 0.0 |

# APPENDIX C

ENDANGERED, THREATENED, AND RARE SPECIES

# Indiana County Endangered, Threatened and Rare Species List

## County: Boone

| Species Name | Common Name | FED | STATE | GRANK | SRANK |
|---|---|---|---|---|---|
| **Mollusk: Bivalvia (Mussels)** | | | | | |
| Alasmidonta viridis | Slippershell Mussel | | | G4G5 | S2 |
| Fusconaia subrotunda | Longsolid | | SE | G3 | S1 |
| Lampsilis fasciola | Wavyrayed Lampmussel | | SSC | G4 | S2 |
| Ptychobranchus fasciolaris | Kidneyshell | | SSC | G4G5 | S2 |
| Toxolasma lividus | Purple Lilliput | | SSC | G2 | S2 |
| Toxolasma parvum | Lilliput | | | G5 | S2 |
| Villosa lienosa | Little Spectaclecase | | SSC | G5 | S2 |
| **Bird** | | | | | |
| Ardea herodias | Great Blue Heron | | | G5 | S4B |
| Bartramia longicauda | Upland Sandpiper | | SE | G5 | S3B |
| Buteo lineatus | Red-shouldered Hawk | | SSC | G5 | S3 |
| Cistothorus palustris | Marsh Wren | | SE | G5 | S3B |
| Cistothorus platensis | Sedge Wren | | SE | G5 | S3B |
| Dendroica cerulea | Cerulean Warbler | | SSC | G4 | S3B |
| Helmitheros vermivorus | Worm-eating Warbler | | SSC | G5 | S3B |
| Ixobrychus exilis | Least Bittern | | SE | G5 | S3B |
| Mniotilta varia | Black-and-white Warbler | | SSC | G5 | S1S2B |
| Nycticorax nycticorax | Black-crowned Night-heron | | SE | G5 | S1B |
| Rallus elegans | King Rail | | SE | G4 | S1B |
| Rallus limicola | Virginia Rail | | SE | G5 | S3B |
| Tyto alba | Barn Owl | | SE | G5 | S2 |
| Wilsonia citrina | Hooded Warbler | | SSC | G5 | S3B |
| **Mammal** | | | | | |
| Myotis sodalis | Indiana Bat or Social Myotis | LE | SE | G2 | S1 |
| Taxidea taxus | American Badger | | | G5 | S2 |
| **Vascular Plant** | | | | | |
| Crataegus grandis | Grand Hawthorn | | SE | G3G5Q | S1 |
| Juglans cinerea | Butternut | | WL | G3G4 | S3 |
| Plantago cordata | Heart-leaved Plantain | | SE | G4 | S1 |
| **High Quality Natural Community** | | | | | |
| Forest - flatwoods central till plain | Central Till Plain Flatwoods | | SG | G3 | S2 |

Indiana Natural Heritage Data Center
Division of Nature Preserves
Indiana Department of Natural Resources
This data is not the result of comprehensive county surveys.

Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting

State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list

GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank

SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

# Indiana County Endangered, Threatened and Rare Species List

## County: Clay

| Species Name | Common Name | FED | STATE | GRANK | SRANK |
|---|---|---|---|---|---|
| **Fish** | | | | | |
| Ammocrypta pellucida | Eastern Sand Darter | | | G3 | S2 |
| Cycleptus elongatus | Blue Sucker | | | G3G4 | S2 |
| **Reptile** | | | | | |
| Clonophis kirtlandii | Kirtland's Snake | | SE | G2 | S2 |
| Crotalus horridus | Timber Rattlesnake | | SE | G4 | S2 |
| Nerodia erythrogaster neglecta | Copperbelly Water Snake | PS:LT | SE | G5T2T3 | S2 |
| Terrapene ornata | Ornate Box Turtle | | SE | G5 | S2 |
| Thamnophis proximus | Western Ribbon Snake | | SSC | G5 | S3 |
| **Bird** | | | | | |
| Bartramia longicauda | Upland Sandpiper | | SE | G5 | S3B |
| Buteo lineatus | Red-shouldered Hawk | | SSC | G5 | S3 |
| Lanius ludovicianus | Loggerhead Shrike | No Status | SE | G4 | S3B |
| **Mammal** | | | | | |
| Lutra canadensis | Northern River Otter | | | G5 | S2 |
| Lynx rufus | Bobcat | No Status | | G5 | S1 |
| Myotis sodalis | Indiana Bat or Social Myotis | LE | SE | G2 | S1 |
| Nycticeius humeralis | Evening Bat | | SE | G5 | S1 |
| Taxidea taxus | American Badger | | | G5 | S2 |
| **Vascular Plant** | | | | | |
| Carex atlantica ssp. atlantica | Atlantic Sedge | | ST | G5T4 | S2 |
| **High Quality Natural Community** | | | | | |
| Wetland - seep acid | Acid Seep | | SG | GU | S1 |

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SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

# Indiana County Endangered, Threatened and Rare Species List

## County: Hendricks

| Species Name | Common Name | FED | STATE | GRANK | SRANK |
|---|---|---|---|---|---|
| **Mollusk: Bivalvia (Mussels)** | | | | | |
| Villosa lienosa | Little Spectaclecase | | SSC | G5 | S2 |
| **Reptile** | | | | | |
| Sistrurus catenatus catenatus | Eastern Massasauga | C | SE | G3G4T3T4 | S2 |
| **Bird** | | | | | |
| Ardea herodias | Great Blue Heron | | | G5 | S4B |
| Bartramia longicauda | Upland Sandpiper | | SE | G5 | S3B |
| Cistothorus platensis | Sedge Wren | | SE | G5 | S3B |
| Dendroica cerulea | Cerulean Warbler | | SSC | G4 | S3B |
| Haliaeetus leucocephalus | Bald Eagle | LT,PDL | SE | G5 | S2 |
| **Mammal** | | | | | |
| Lynx rufus | Bobcat | No Status | | G5 | S1 |
| Myotis sodalis | Indiana Bat or Social Myotis | LE | SE | G2 | S1 |
| Nycticeius humeralis | Evening Bat | | SE | G5 | S1 |
| Taxidea taxus | American Badger | | | G5 | S2 |
| **Vascular Plant** | | | | | |
| Juglans cinerea | Butternut | | WL | G3G4 | S3 |
| Poa paludigena | Bog Bluegrass | | WL | G3 | S3 |
| **High Quality Natural Community** | | | | | |
| Forest - flatwoods central till plain | Central Till Plain Flatwoods | | SG | G3 | S2 |
| Wetland - seep circumneutral | Circumneutral Seep | | SG | GU | S1 |

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SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

# Indiana County Endangered, Threatened and Rare Species List

## County: Parke

| Species Name | Common Name | FED | STATE | GRANK | SRANK |
|---|---|---|---|---|---|
| **Mollusk: Bivalvia (Mussels)** | | | | | |
| Epioblasma obliquata obliquata | Purple Catspaw | LE | SX | G1T1 | SX |
| Epioblasma propinqua | Tennessee Riffleshell | | SX | GX | SX |
| Lampsilis teres | Yellow Sandshell | | | G5 | S2 |
| Obovaria retusa | Ring Pink | LE | SX | G1 | SX |
| Obovaria subrotunda | Round Hickorynut | | SSC | G4 | S2 |
| Plethobasus cyphyus | Sheepnose | C | SE | G3 | S1 |
| Pleurobema clava | Clubshell | LE | SE | G2 | S1 |
| Quadrula cylindrica cylindrica | Rabbitsfoot | | SE | G3T3 | S1 |
| Simpsonaias ambigua | Salamander Mussel | | SSC | G3 | S2 |
| **Insect: Lepidoptera (Butterflies & Moths)** | | | | | |
| Amblyscirtes hegon | Salt-and-pepper Skipper | | SR | G5 | S2 |
| **Insect: Odonata (Dragonflies & Damselflies)** | | | | | |
| Cordulegaster bilineata | Brown Spiketail | | SE | G5 | S1 |
| Erpetogomphus designatus | Eastern Ringtail | | ST | G5 | S2 |
| Hagenius brevistylus | Dragonhunter | | SR | G5 | S2S3 |
| Tachopteryx thoreyi | Gray Petaltail | | SR | G4 | S2S3 |
| **Fish** | | | | | |
| Ammocrypta pellucida | Eastern Sand Darter | | | G3 | S2 |
| Cycleptus elongatus | Blue Sucker | | | G3G4 | S2 |
| Etheostoma camurum | Bluebreast Darter | | | G4 | S1 |
| Hybopsis amblops | Bigeye Chub | | | G5 | S2 |
| Moxostoma valenciennesi | Greater Redhorse | | SE | G4 | S2 |
| Notropis ariommus | Popeye Shiner | | SX | G3 | SX |
| Percina evides | Gilt Darter | | SE | G4 | S1 |
| **Amphibian** | | | | | |
| Rana pipiens | Northern Leopard Frog | | SSC | G5 | S2 |
| **Reptile** | | | | | |
| Clonophis kirtlandii | Kirtland's Snake | | SE | G2 | S2 |
| Crotalus horridus | Timber Rattlesnake | | SE | G4 | S2 |
| **Bird** | | | | | |
| Aimophila aestivalis | Bachman's Sparrow | | | G3 | SXB |
| Ammodramus henslowii | Henslow's Sparrow | | SE | G4 | S3B |
| Ardea herodias | Great Blue Heron | | | G5 | S4B |
| Buteo lineatus | Red-shouldered Hawk | | SSC | G5 | S3 |
| Buteo platypterus | Broad-winged Hawk | No Status | SSC | G5 | S3B |
| Circus cyaneus | Northern Harrier | | SE | G5 | S2 |
| Dendroica cerulea | Cerulean Warbler | | SSC | G4 | S3B |
| Haliaeetus leucocephalus | Bald Eagle | LT,PDL | SE | G5 | S2 |
| Helmitheros vermivorus | Worm-eating Warbler | | SSC | G5 | S3B |
| Lanius ludovicianus | Loggerhead Shrike | No Status | SE | G4 | S3B |
| Lophodytes cucullatus | Hooded Merganser | | | G5 | S2S3B |
| Mniotilta varia | Black-and-white Warbler | | SSC | G5 | S1S2B |
| Pandion haliaetus | Osprey | | SE | G5 | S1B |
| **Mammal** | | | | | |
| Lynx rufus | Bobcat | No Status | | G5 | S1 |
| Mustela nivalis | Least Weasel | | SSC | G5 | S2? |
| Myotis sodalis | Indiana Bat or Social Myotis | LE | SE | G2 | S1 |
| Nycticeius humeralis | Evening Bat | | SE | G5 | S1 |
| Taxidea taxus | American Badger | | | G5 | S2 |
| **Vascular Plant** | | | | | |
| Acalypha deamii | Mercury | | SR | G4? | S2 |
| Carex aurea | Golden-fruited Sedge | | SR | G5 | S2 |
| Carex pedunculata | Longstalk Sedge | | SR | G5 | S2 |

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SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

# Indiana County Endangered, Threatened and Rare Species List

## County: Parke

| Species Name | Common Name | FED | STATE | GRANK | SRANK |
|---|---|---|---|---|---|
| Chelone obliqua var. speciosa | Rose Turtlehead | | WL | G4T3 | S3 |
| Cypripedium calceolus var. parviflorum | Small Yellow Lady's-slipper | | SR | G5 | S2 |
| Euphorbia obtusata | Bluntleaf Spurge | | SE | G5 | S1 |
| Fragaria vesca var. americana | Woodland Strawberry | | SE | G5T5 | S1 |
| Hypericum pyramidatum | Great St. John's-wort | | ST | G4 | S1 |
| Matteuccia struthiopteris | Ostrich Fern | | SR | G5 | S2 |
| Napaea dioica | Glade Mallow | | SR | G3 | S2 |
| Panax quinquefolius | American Ginseng | | WL | G3G4 | S3 |
| Pinus strobus | Eastern White Pine | | SR | G5 | S2 |
| Platanthera psycodes | Small Purple-fringe Orchis | | SR | G5 | S2 |
| Poa wolfii | Wolf Bluegrass | | SR | G4 | S2 |
| Rubus centralis | Illinois Blackberry | | SE | G2?Q | S1 |
| Rudbeckia fulgida var. umbrosa | Coneflower | | SE | G5T4T5 | S1 |
| Selaginella rupestris | Ledge Spike-moss | | ST | G5 | S2 |
| Silene regia | Royal Catchfly | | ST | G3 | S2 |
| Spiranthes lucida | Shining Ladies'-tresses | | SR | G5 | S2 |
| Taxus canadensis | American Yew | | SE | G5 | S1 |
| Trillium cernuum var. macranthum | Nodding Trillium | | SE | G5T4 | S1 |
| Viburnum molle | Softleaf Arrow-wood | | SR | G5 | S2 |
| **High Quality Natural Community** | | | | | |
| Forest - floodplain mesic | Mesic Floodplain Forest | | SG | G3? | S1 |
| Forest - floodplain wet | Wet Floodplain Forest | | SG | G3? | S3 |
| Forest - floodplain wet-mesic | Wet-mesic Floodplain Forest | | SG | G3? | S3 |
| Forest - upland dry-mesic | Dry-mesic Upland Forest | | SG | G4 | S4 |
| Forest - upland mesic | Mesic Upland Forest | | SG | G3? | S3 |
| Primary - cliff limestone | Limestone Cliff | | SG | GU | S1 |
| Primary - cliff sandstone | Sandstone Cliff | | SG | GU | S3 |
| Wetland - fen | Fen | | SG | G3 | S3 |
| Wetland - marsh | Marsh | | SG | GU | S4 |
| Wetland - seep circumneutral | Circumneutral Seep | | SG | GU | S1 |



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State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list
GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank
SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

# Indiana County Endangered, Threatened and Rare Species List

## County: Putnam

| Species Name | Common Name | FED | STATE | GRANK | SRANK |
|---|---|---|---|---|---|
| **Mollusk: Bivalvia (Mussels)** | | | | | |
| Lampsilis fasciola | Wavyrayed Lampmussel | | SSC | G4 | S2 |
| Ptychobranchus fasciolaris | Kidneyshell | | SSC | G4G5 | S2 |
| Simpsonaias ambigua | Salamander Mussel | | SSC | G3 | S2 |
| Toxolasma lividus | Purple Lilliput | | SSC | G2 | S2 |
| Villosa lienosa | Little Spectaclecase | | SSC | G5 | S2 |
| **Insect: Coleoptera (Beetles)** | | | | | |
| Dryobius sexnotatus | Six-banded Longhorn Beetle | | ST | GNR | SNR |
| **Insect: Lepidoptera (Butterflies & Moths)** | | | | | |
| Amblyscirtes hegon | Salt-and-pepper Skipper | | SR | G5 | S2 |
| Eosphoropteryx thyatyroides | Pinkpatched Looper Moth | | ST | G4G5 | S2 |
| **Insect: Odonata (Dragonflies & Damselflies)** | | | | | |
| Cordulegaster obliqua | Arrowhead Spiketail | | SR | G4 | S2S3 |
| **Fish** | | | | | |
| Ammocrypta pellucida | Eastern Sand Darter | | | G3 | S2 |
| Cycleptus elongatus | Blue Sucker | | | G3G4 | S2 |
| **Amphibian** | | | | | |
| Rana pipiens | Northern Leopard Frog | | SSC | G5 | S2 |
| **Reptile** | | | | | |
| Crotalus horridus | Timber Rattlesnake | | SE | G4 | S2 |
| Opheodrys aestivus | Rough Green Snake | | SSC | G5 | S3 |
| **Bird** | | | | | |
| Aimophila aestivalis | Bachman's Sparrow | | | G3 | SXB |
| Ardea herodias | Great Blue Heron | | | G5 | S4B |
| Buteo lineatus | Red-shouldered Hawk | | SSC | G5 | S3 |
| Coragyps atratus | Black Vulture | | | G5 | S1N,S2B |
| Dendroica cerulea | Cerulean Warbler | | SSC | G4 | S3B |
| Haliaeetus leucocephalus | Bald Eagle | LT,PDL | SE | G5 | S2 |
| Helmitheros vermivorus | Worm-eating Warbler | | SSC | G5 | S3B |
| Wilsonia citrina | Hooded Warbler | | SSC | G5 | S3B |
| **Mammal** | | | | | |
| Lutra canadensis | Northern River Otter | | | G5 | S2 |
| Lynx rufus | Bobcat | No Status | | G5 | S1 |
| Mustela nivalis | Least Weasel | | SSC | G5 | S2? |
| Myotis sodalis | Indiana Bat or Social Myotis | LE | SE | G2 | S1 |
| Taxidea taxus | American Badger | | | G5 | S2 |
| **Vascular Plant** | | | | | |
| Carex pedunculata | Longstalk Sedge | | SR | G5 | S2 |
| Carex sparganioides var. cephaloidea | Thinleaf Sedge | | SE | G5 | S2 |
| Chelone obliqua var. speciosa | Rose Turtlehead | | WL | G4T3 | S3 |
| Juglans cinerea | Butternut | | WL | G3G4 | S3 |
| Poa wolfii | Wolf Bluegrass | | SR | G4 | S2 |
| Taxus canadensis | American Yew | | SE | G5 | S1 |
| **High Quality Natural Community** | | | | | |
| Forest - floodplain mesic | Mesic Floodplain Forest | | SG | G3? | S1 |
| Forest - floodplain wet-mesic | Wet-mesic Floodplain Forest | | SG | G3? | S3 |
| Forest - upland dry-mesic | Dry-mesic Upland Forest | | SG | G4 | S4 |
| Forest - upland mesic | Mesic Upland Forest | | SG | G3? | S3 |
| Primary - cliff overhang | Sandstone Overhang | | SG | G4 | S2 |
| Primary - cliff sandstone | Sandstone Cliff | | SG | GU | S3 |



Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting

State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list

GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank

SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

# APPENDIX D

## BIG WALNUT CREEK WATERSHED LISTED 303d STREAMS

**2006 303d List**

| BASIN | 14-DIGIT HUC | COUNTY | WATERBODY SEGMENT ID | WATERBODY SEGMENT NAME | CAUSE OF IMPAIRMENT |
|---|---|---|---|---|---|
| WEST FORK WHITE | 5120203010010 | BOONE CO | INW0311_00 | WEST FORK BIG WALNUT CREEK-HEADWATERS | E. COLI |
| WEST FORK WHITE | 5120203010020 | BOONE CO | INW0312_00 | MAIN EDLIN DITCH-SMITH DITCH | E. COLI |
| WEST FORK WHITE | 5120203010030 | BOONE CO | INW0313_00 | MAIN EDLIN DITCH-GRASSY BRANCH | E. COLI |
| WEST FORK WHITE | 5120203010040 | HENDRICKS CO | INW0314_00 | WEST FORK BIG WALNUT CREEK-LOWER | E. COLI |
| WEST FORK WHITE | 5120203010060 | HENDRICKS CO | INW0316_00 | EAST FORK BIG WALNUT CREEK-ROSS DITCH | E. COLI |
| WEST FORK WHITE | 5120203010070 | HENDRICKS CO | INW0317_00 | EAST FORK BIG WALNUT CREEK-LOWER | E. COLI |
| WEST FORK WHITE | 5120203020010 | PUTNAM CO | INW0321_00 | BIG WALNUT-BARNARD TRIBUTARIES | E. COLI |
| WEST FORK WHITE | 5120203020010 | PUTNAM CO | INW0321_T1001 | BIG WALNUT CREEK | E. COLI; FCA for MERCURY |
| WEST FORK WHITE | 5120203020020 | PUTNAM CO | INW0322_T1002 | BIG WALNUT CREEK-ERNIE PYLE MEMORIAL | E. COLI; FCA for MERCURY |
| WEST FORK WHITE | 5120203020030 | PUTNAM CO | INW0323_00 | BLEDSOE BRANCH BASIN | E. COLI |
| WEST FORK WHITE | 5120203020030 | PUTNAM CO | INW0323_T1003 | BIG WALNUT CREEK | E. COLI; FCA for MERCURY |
| WEST FORK WHITE | 5120203020040 | PUTNAM CO | INW0324_00 | CLEAR CREEK-HEADWATERS (PUTNAM) | E. COLI |
| WEST FORK WHITE | 5120203020050 | PUTNAM CO | INW0325_00 | CLEAR CREEK-MILLER CREEK | E. COLI |
| WEST FORK WHITE | 5120203020060 | PUTNAM CO | INW0326_T1004 | BIG WALNUT CREEK | E. COLI; FCA for MERCURY |
| WEST FORK WHITE | 5120203020070 | PUTNAM CO | INW0327_T1005 | BIG WALNUT CREEK | E. COLI; FCA for MERCURY |
| WEST FORK WHITE | 5120203030010 | PUTNAM CO | INW0331_00 | OWL CREEK | E. COLI |

**2006 303d List**

| BASIN | 14-DIGIT HUC | COUNTY | WATERBODY SEGMENT ID | WATERBODY SEGMENT NAME | CAUSE OF IMPAIRMENT |
|---|---|---|---|---|---|
| WEST FORK WHITE | 5120203030020 | PUTNAM CO | INW0332_00 | LITTLE WALNUT CREEK-HEADWATERS | E. COLI |
| WEST FORK WHITE | 5120203030030 | PUTNAM CO | INW0333_00 | JONES CREEK TRIBUTARIES | E. COLI |
| WEST FORK WHITE | 5120203030030 | PUTNAM CO | INW0333_T1008 | JONES CREEK | E. COLI; IMPAIRED BIOTIC COMMUNITIES |
| WEST FORK WHITE | 5120203030040 | PUTNAM CO | INW0334_00 | LITTLE WALNUT CREEK-LEATHERMAN CREEK | E. COLI |
| WEST FORK WHITE | 5120203030050 | PUTNAM CO | INW0335_00 | LITTLE WALNUT CREEK-LONG BRANCH | E. COLI |
| WEST FORK WHITE | 5120203040010 | PUTNAM CO | INW0341_T1006 | BIG WALNUT CREEK | E. COLI; FCA for MERCURY |
| WEST FORK WHITE | 5120203040010 | PUTNAM CO | INW0341_T1027 | MAIDEN RUN | IMPAIRED BIOTIC COMMUNITIES |
| WEST FORK WHITE | 5120203040020 | PUTNAM CO | INW0342_00 | MILL CREEK | E. COLI |
| WEST FORK WHITE | 5120203040020 | PUTNAM CO | INW0342_T1007 | BIG WALNUT CREEK | E. COLI; FCA for MERCURY |
| WEST FORK WHITE | 5120203050020 | PUTNAM CO | INW0352_T1009 | LITTLE DEER CREEK | IMPAIRED BIOTIC COMMUNITIES |
| WEST FORK WHITE | 5120203050050 | PUTNAM CO | INW0355_00 | DEER CREEK-MOSQUITO CREEK | E. COLI |
| WEST FORK WHITE | 5120203050060 | PUTNAM CO | INW0356_00 | DEWEESE CREEK | E. COLI |
| WEST FORK WHITE | 5120203050070 | PUTNAM CO | INW0357_00 | DEER CREEK-LEATHERWOOD CREEK | E. COLI |

**2008 303d List**

| BASIN | 14-DIGIT HUC | COUNTY | WATERBODY SEGMENT ID | WATERBODY SEGMENT NAME | CAUSE OF IMPAIRMENT |
|---|---|---|---|---|---|
| WEST FORK WHITE | 5120203010010 | BOONE CO | INW0311_00 | WEST FORK BIG WALNUT CREEK-HEADWATERS | E. COLI |
| WEST FORK WHITE | 5120203010020 | BOONE CO | INW0312_00 | MAIN EDLIN DITCH-SMITH DITCH | E. COLI |
| WEST FORK WHITE | 5120203010030 | BOONE CO | INW0313_00 | MAIN EDLIN DITCH-GRASSY BRANCH | E. COLI |
| WEST FORK WHITE | 5120203010040 | HENDRICKS CO | INW0314_00 | WEST FORK BIG WALNUT CREEK-LOWER | E. COLI |
| WEST FORK WHITE | 5120203010060 | HENDRICKS CO | INW0316_00 | EAST FORK BIG WALNUT CREEK-ROSS DITCH | E. COLI |
| WEST FORK WHITE | 5120203010070 | HENDRICKS CO | INW0317_00 | EAST FORK BIG WALNUT CREEK-LOWER | E. COLI |
| WEST FORK WHITE | 5120203020010 | PUTNAM CO | INW0321_00 | BIG WALNUT-BARNARD TRIBUTARIES | E. COLI |
| WEST FORK WHITE | 5120203020010 | PUTNAM CO | INW0321_T1001 | BIG WALNUT CREEK | E. COLI |
| WEST FORK WHITE | 5120203020020 | PUTNAM CO | INW0322_T1002 | BIG WALNUT CREEK-ERNIE PYLE MEMORIAL | E. COLI |
| WEST FORK WHITE | 5120203020030 | PUTNAM CO | INW0323_00 | BLEDSOE BRANCH BASIN | E. COLI |
| WEST FORK WHITE | 5120203020030 | PUTNAM CO | INW0323_T1003 | BIG WALNUT CREEK | E. COLI |
| WEST FORK WHITE | 5120203020040 | PUTNAM CO | INW0324_00 | CLEAR CREEK-HEADWATERS (PUTNAM) | E. COLI |
| WEST FORK WHITE | 5120203020050 | PUTNAM CO | INW0325_00 | CLEAR CREEK-MILLER CREEK | E. COLI |
| WEST FORK WHITE | 5120203020060 | PUTNAM CO | INW0326_T1004 | BIG WALNUT CREEK | E. COLI |
| WEST FORK WHITE | 5120203020070 | PUTNAM CO | INW0327_T1005 | BIG WALNUT CREEK | E. COLI |
| WEST FORK WHITE | 5120203030010 | PUTNAM CO | INW0331_00 | OWL CREEK | E. COLI |

**2008 303d List**

| BASIN | 14-DIGIT HUC | COUNTY | WATERBODY SEGMENT ID | WATERBODY SEGMENT NAME | CAUSE OF IMPAIRMENT |
|---|---|---|---|---|---|
| WEST FORK WHITE | 5120203030020 | PUTNAM CO | INW0332_00 | LITTLE WALNUT CREEK-HEADWATERS | E. COLI |
| WEST FORK WHITE | 5120203030030 | PUTNAM CO | INW0333_00 | JONES CREEK TRIBUTARIES | E. COLI |
| WEST FORK WHITE | 5120203030030 | PUTNAM CO | INW0333_T1008 | JONES CREEK | E. COLI: IMPAIRED BIOTIC COMMUNITIES |
| WEST FORK WHITE | 5120203030040 | PUTNAM CO | INW0334_00 | LITTLE WALNUT CREEK-LEATHERMAN CREEK | E. COLI |
| WEST FORK WHITE | 5120203030050 | PUTNAM CO | INW0335_00 | LITTLE WALNUT CREEK-LONG BRANCH | E. COLI |
| WEST FORK WHITE | 5120203040010 | PUTNAM CO | INW0341_T1006 | BIG WALNUT CREEK | E. COLI |
| WEST FORK WHITE | 5120203040010 | PUTNAM CO | INW0341_T1027 | MAIDEN RUN | IMPAIRED BIOTIC COMMUNITIES |
| WEST FORK WHITE | 5120203040020 | PUTNAM CO | INW0342_00 | MILL CREEK | E. COLI; FCA for MERCURY |
| WEST FORK WHITE | 5120203040020 | PUTNAM CO | INW0342_T1007 | BIG WALNUT CREEK | E. COLI; FCA for MERCURY |
| WEST FORK WHITE | 5120203050020 | PUTNAM CO | INW0352_T1009 | LITTLE DEER CREEK | IMPAIRED BIOTIC COMMUNITIES |
| WEST FORK WHITE | 5120203050050 | PUTNAM CO | INW0355_00 | DEER CREEK-MOSQUITO CREEK | E. COLI |
| WEST FORK WHITE | 5120203050060 | PUTNAM CO | INW0356_00 | DEWEESE CREEK | E. COLI |
| WEST FORK WHITE | 5120203050070 | PUTNAM CO | INW0357_00 | DEER CREEK-LEATHERWOOD CREEK | E. COLI |

# APPENDIX E
RAW CONCENTRATION DATA

## Raw Concentration Data

| Dissolved Oxygen (mg/L) | | | | | | |
|---|---|---|---|---|---|---|
| | **5/29/2007** | **7/11/2007** | **8/28/2007** | **1/8/2008** | **4/10/2008** | **6/4/2008** |
| | Storm | Base | Base | Storm | Base | Storm |
| **Site 1 -** Watershed X, Y | 8.1 | 7.3 | 6.7 | 9.5 | 10.5 | 7.0 |
| **Site 2 -** Watershed CC | 12 | 6.3 | 5.0 | 10.5 | 10.6 | 6.7 |
| **Site 3 -** Watershed Z | 9.1 | 8.4 | 9.4 | 10.5 | 11.9 | 7.8 |
| **Site 4 -** Watershed P, Q | 9.1 | 7.5 | 8.0 | 9.6 | 11.6 | 6.8 |
| **Site 5 -** Watershed BB, R | 8.6 | 5.7 | 6.4 | 10.0 | 10.5 | 8.0 |
| **Site 6 -** Watershed DD | 9 | 8.2 | 8.4 | 10.0 | 10.9 | 7.9 |
| **Site 7 -** Watersheds A, C, F | 8.7 | 6.8 | 7.0 | 9.8 | 10.6 | 8.0 |
| **Site 8 -** Watershed B, D | 11.1 | 8.6 | 7.8 | 12.4 | 11.9 | 8.1 |
| **Site 9 -** Watershed E, G | 9.7 | 8.1 | 8.2 | 12.8 | 11.7 | 9.7 |
| **Site 10 -** Watershed H | 6.7 | 7.8 | 7.5 | 9.8 | 10.7 | 8.2 |
| **Site 11 -** Watershed H | 8.1 | 5.0 | 3.6 | 9.9 | 10.2 | 8.1 |
| **Site 12 -** Watershed I | 8.9 | 4.2 | 4.4 | 8.1 | 10.5 | 8.2 |
| **Site 13 -** Watershed I | 8 | 8.4 | 4.7 | 9.4 | 10.2 | 7.9 |
| **Site 14 -** Watershed F | 10.6 | 8.2 | 7.3 | 9.8 | 10.5 | 8.4 |
| **Site 15 -** Watershed AA | 9.8 | 6.2 | 6.6 | 11.2 | 13.1 | 12.4 |
| **Site 16 -** Watershed S | 10.1 | 7.7 | 6.7 | 12.5 | 13.4 | 15.2 |
| **Site 17 -** Watershed S | 8.7 | 6.7 | 3.3 | 12.6 | 13.9 | 14.8 |
| **Site 18 -** Watershed W | 9.8 | 7.4 | 6.5 | 13.1 | 13.7 | 8.7 |
| **Site 19 -** Watershed U, V | 11.3 | 8.5 | 7.0 | 11.7 | 12.7 | 14.2 |
| **Site 20 -** Watershed G | 8.9 | 7.6 | 8.1 | 12.7 | 13.6 | 7.8 |
| **Site 21 -** Watershed L, J | 10.1 | 6.4 | 6.8 | 12.2 | 13.1 | 9.4 |
| **Site 22 -** Watershed T | 9 | 8.1 | 6.8 | 14.2 | 12.5 | 10.2 |
| **Site 23 -** Watershed O | 10.2 | 6.7 | 6.8 | 12.2 | 12.0 | 9.2 |
| **Site 24 -** Watershed K, M, N | 8.6 | 6.1 | 7.3 | 13.1 | 11.6 | 9.3 |

## Raw Concentration Data

| Nitrate (mg/L) | | | | | | |
|---|---|---|---|---|---|---|
| | **5/29/2007** | **7/11/2007** | **8/28/2007** | **1/8/2008** | **4/10/2008** | **6/4/2008** |
| | Storm | Base | Base | Storm | Base | Storm |
| **Site 1 -** Watershed X, Y | 1.2 | 0.7 | 1.5 | 7.5 | 6.0 | 3.8 |
| **Site 2 -** Watershed CC | 3 | 0.7 | 3.0 | 8.0 | 7.5 | 2.8 |
| **Site 3 -** Watershed Z | 2.6 | 2.4 | 1.8 | 6.5 | 5.2 | 4.2 |
| **Site 4 -** Watershed P, Q | 1.9 | 0.7 | 1.2 | 7.5 | 6.0 | 3.5 |
| **Site 5 -** Watershed BB, R | 2.1 | 0.4 | 1.3 | 6.5 | 6.0 | 1.9 |
| **Site 6 -** Watershed DD | 1.8 | 0.4 | 1.2 | 5.6 | 6.0 | 2.0 |
| **Site 7 -** Watersheds A, C, F | 1.8 | 0.4 | 0.8 | 5.6 | 4.8 | 3.5 |
| **Site 8 -** Watershed B, D | 1.9 | 1.1 | 1.3 | 4.4 | 2.0 | 1.9 |
| **Site 9 -** Watershed E, G | 1.3 | 0.4 | 0.7 | 3.8 | 3.2 | 2.2 |
| **Site 10 -** Watershed H | 0.7 | 0.2 | 0.7 | 3.0 | 2.8 | 4.0 |
| **Site 11 -** Watershed H | 3.2 | 0.6 | 0.7 | 6.5 | 5.2 | 4.8 |
| **Site 12 -** Watershed I | 0.9 | 0.2 | 0.7 | 4.2 | 2.4 | 3.8 |
| **Site 13 -** Watershed I | 2.6 | 0.6 | 1.0 | 4.4 | 3.2 | 2.4 |
| **Site 14 -** Watershed F | 0.9 | 0.4 | 0.6 | 3.5 | 2.5 | 3.5 |
| **Site 15 -** Watershed AA | 3 | 0.6 | 0.9 | 6.0 | 1.9 | 4.0 |
| **Site 16 -** Watershed S | 3.5 | 0.6 | 0.8 | 5.0 | 5.0 | 2.4 |
| **Site 17 -** Watershed S | 2.4 | 0.9 | 0.9 | 5.8 | 3.7 | 2.2 |
| **Site 18 -** Watershed W | 1.4 | 0.8 | 0.7 | 2.2 | 1.5 | 2.4 |
| **Site 19 -** Watershed U, V | 2.8 | 1.1 | 1.3 | 2.2 | 2.4 | 1.6 |
| **Site 20 -** Watershed G | 1.2 | 0.5 | 0.5 | 0.7 | 0.7 | 1.3 |
| **Site 21 -** Watershed L, J | 1.9 | 0.4 | 1.0 | 4.0 | 3.5 | 2.9 |
| **Site 22 -** Watershed T | 10 | 0.9 | 1.3 | 3.0 | 2.4 | 2.9 |
| **Site 23 -** Watershed O | 2.6 | 0.6 | 1.0 | 2.2 | 1.2 | 1.6 |
| **Site 24 -** Watershed K, M, N | 3.5 | 0.8 | 1.0 | 3.5 | 2.1 | 1.6 |

**Raw Concentration Data**

| **Total Phosphorus (mg/L)** | | | | | | |
|---|---|---|---|---|---|---|
| | **5/29/2007** | **7/11/2007** | **8/28/2007** | **1/8/2008** | **4/10/2008** | **6/4/2008** |
| | Storm | Base | Base | Storm | Base | Storm |
| **Site 1 -** Watershed X, Y | 0.22 | 0.26 | 0.13 | 0.04 | 0.03 | 0.40 |
| **Site 2 -** Watershed CC | 0.04 | 0.1 | 0.08 | 0.04 | 0.05 | 0.95 |
| **Site 3 -** Watershed Z | 0.26 | 0.1 | 0.24 | 0.03 | 0.09 | 0.80 |
| **Site 4 -** Watershed P, Q | 0.17 | 0.35 | 0.19 | 0.06 | 0.16 | 0.52 |
| **Site 5 -** Watershed BB, R | 0.17 | 0.2 | 0.09 | 0.06 | 0.06 | 0.95 |
| **Site 6 -** Watershed DD | 0.43 | 0.32 | 0.19 | 0.05 | 0.05 | 0.42 |
| **Site 7 -** Watersheds A, C, F | 0.24 | 0.08 | 0.16 | 0.05 | 0.08 | 0.52 |
| **Site 8 -** Watershed B, D | 0.25 | 0.18 | 0.19 | 0.05 | 0.08 | 0.52 |
| **Site 9 -** Watershed E, G | 0.4 | 0.24 | 0.26 | 0.05 | 0.13 | 0.60 |
| **Site 10 -** Watershed H | 0.24 | 0.1 | 0.08 | 0.06 | 0.06 | 0.80 |
| **Site 11 -** Watershed H | 0.6 | 0.21 | 0.35 | 0.06 | 0.13 | 0.95 |
| **Site 12 -** Watershed I | 0.56 | 0.24 | 0.20 | 0.05 | 0.07 | 0.95 |
| **Site 13 -** Watershed I | 0.19 | 0.11 | 0.14 | 0.10 | 0.09 | 0.90 |
| **Site 14 -** Watershed F | 0.03 | 0.11 | 0.32 | 0.06 | 0.07 | 0.52 |
| **Site 15 -** Watershed AA | 0.24 | 0.19 | 0.22 | 0.07 | 0.07 | 0.38 |
| **Site 16 -** Watershed S | 0.24 | 0.14 | 0.18 | 0.06 | 0.20 | 0.42 |
| **Site 17 -** Watershed S | 0.12 | 0.22 | 0.12 | 0.07 | 0.09 | 0.24 |
| **Site 18 -** Watershed W | 0.35 | 0.14 | 0.22 | 0.07 | 0.03 | 0.22 |
| **Site 19 -** Watershed U, V | 0.09 | 0.09 | 0.24 | 0.10 | 0.03 | 0.18 |
| **Site 20 -** Watershed G | 0.06 | 0.32 | 0.15 | 0.09 | 0.03 | 0.24 |
| **Site 21 -** Watershed L, J | 0.12 | 0.11 | 0.28 | 0.06 | 0.04 | 0.80 |
| **Site 22 -** Watershed T | 0.15 | 0.15 | 0.12 | 0.12 | 0.17 | 0.38 |
| **Site 23 -** Watershed O | 0.15 | 0.22 | 0.14 | 0.10 | 0.07 | 0.22 |
| **Site 24 -** Watershed K, M, N | 0.75 | 0.18 | 0.24 | .08 | .05 | 0.24 |

## Raw Concentration Data

| Total Suspended Solids (mg/L) | | | | | | |
|---|---|---|---|---|---|---|
| | **5/29/2007** | **7/11/2007** | **8/28/2007** | **1/8/2008** | **4/10/2008** | **6/4/2008** |
| | Storm | Base | Base | Storm | Base | Storm |
| **Site 1 -** Watershed X, Y | 4.5 | 7.0 | 5.0 | 15.0 | 8.0 | 540.0 |
| **Site 2 -** Watershed CC | 19 | 4.0 | 13.5 | 9.5 | 14.5 | 448.0 |
| **Site 3 -** Watershed Z | 3 | 4.0 | 5.5 | 3.5 | 2.0 | 242.0 |
| **Site 4 -** Watershed P, Q | 2 | 3.0 | 8.5 | 3.0 | 4.0 | 184.0 |
| **Site 5 -** Watershed BB, R | 4 | 39.5 | 4.5 | 2.5 | 4.0 | 394.0 |
| **Site 6 -** Watershed DD | 3 | 8.5 | 5.5 | 5.5 | 22.0 | 270.0 |
| **Site 7 -** Watersheds A, C, F | 3 | 6.5 | 6.0 | 11.0 | 7.0 | 536.0 |
| **Site 8 -** Watershed B, D | 5 | 9.5 | 5.0 | 11.5 | 11.0 | 900.0 |
| **Site 9 -** Watershed E, G | 7.5 | 9.5 | 8.0 | 11.0 | 23.0 | 938.0 |
| **Site 10 -** Watershed H | 58.5 | 5.0 | 2.0 | 0.5 | 5.0 | 336.0 |
| **Site 11 -** Watershed H | 12.5 | 4.0 | 5.5 | 4.5 | 21.0 | 558.0 |
| **Site 12 -** Watershed I | 5 | 9.0 | 6.5 | 2.0 | 6.2 | 1118.0 |
| **Site 13 -** Watershed I | 7.5 | 27.5 | 4.5 | 16.0 | 9.5 | 452.0 |
| **Site 14 -** Watershed F | 1.5 | 12.0 | 5.5 | 2.0 | 4.5 | 936.0 |
| **Site 15 -** Watershed AA | 1 | 14.0 | 15.5 | 5.5 | 11.5 | 682.0 |
| **Site 16 -** Watershed S | 2 | 2.0 | 2.0 | 0.5 | 4.5 | 338.0 |
| **Site 17 -** Watershed S | 2.5 | 8.0 | 3.0 | 1.0 | 4.5 | 352.0 |
| **Site 18 -** Watershed W | 0.5 | 5.5 | 3.0 | 5.5 | 6.0 | 434.0 |
| **Site 19 -** Watershed U, V | 1.5 | 10.5 | 10.0 | 6.0 | 3.5 | 498.0 |
| **Site 20 -** Watershed G | 0.5 | 2.0 | 0.5 | 1.5 | 2.0 | 294.0 |
| **Site 21 -** Watershed L, J | 1.5 | 20.5 | 2.5 | 1.5 | 4.5 | 386.0 |
| **Site 22 -** Watershed T | 21 | 27.0 | 7.0 | 3.0 | 9.5 | 282.0 |
| **Site 23 -** Watershed O | 4.5 | 5.5 | 5.5 | 3.5 | 8.5 | 240.0 |
| **Site 24 -** Watershed K, M, N | 15.5 | 28.0 | 23.0 | 6.0 | 8.5 | 760.0 |

## Raw Concentration Data

| Biochemical Oxygen Demand (mg/L) | | | | | | |
|---|---|---|---|---|---|---|
| | **5/29/2007** | **7/11/2007** | **8/28/2007** | **1/8/2008** | **4/10/2008** | **6/4/2008** |
| | Storm | Base | Base | Storm | Base | Storm |
| **Site 1 -** Watershed X, Y | 1.8 | 2.9 | 3.0 | 0.8 | 0.6 | 2.8 |
| **Site 2 -** Watershed CC | 1.2 | 1.5 | 3.6 | 1.4 | 0.4 | 6.0 |
| **Site 3 -** Watershed Z | 1.5 | 1.7 | 2.4 | 1.7 | 0.4 | 8.4 |
| **Site 4 -** Watershed P, Q | 1.6 | 2.2 | 3.0 | 1.2 | 0.8 | 6.0 |
| **Site 5 -** Watershed BB, R | 1.8 | 3.1 | 2.9 | 1.6 | 1.1 | 7.2 |
| **Site 6 -** Watershed DD | 1.5 | 2.1 | 3.0 | 1.5 | 1.5 | 3.2 |
| **Site 7 -** Watersheds A, C, F | 1.8 | 2 | 2.8 | 1.4 | 0.1 | 4.4 |
| **Site 8 -** Watershed B, D | 1.5 | 2 | 3.7 | 1.4 | 0.6 | 6.4 |
| **Site 9 -** Watershed E, G | 1.5 | 2.2 | 3.0 | 1.8 | 0.1 | 4.8 |
| **Site 10 -** Watershed H | 3.3 | 1.4 | 2.6 | 1.1 | 0.1 | 6.0 |
| **Site 11 -** Watershed H | 2.6 | 10.2 | 4.5 | 1.1 | 0.3 | 6.0 |
| **Site 12 -** Watershed I | 1.8 | 2.4 | 3.0 | 1.1 | 0.8 | 7.6 |
| **Site 13 -** Watershed I | 1.3 | 2.8 | 3.9 | 1.9 | 2.2 | 8.8 |
| **Site 14 -** Watershed F | 0.8 | 0.8 | 2.1 | 1.4 | 0.6 | 5.6 |
| **Site 15 -** Watershed AA | 1.3 | 2 | 3.8 | 2.2 | 1.3 | 6.8 |
| **Site 16 -** Watershed S | 1.2 | 0.4 | 2.3 | 1.3 | 0.6 | 7.2 |
| **Site 17 -** Watershed S | 1.5 | 2.3 | 2.6 | 1.3 | 0.6 | 4.8 |
| **Site 18 -** Watershed W | 1.6 | 0.4 | 2.1 | 1.4 | 0.9 | 4.4 |
| **Site 19 -** Watershed U, V | 2.1 | 1.4 | 2.3 | 2.1 | 0.0 | 5.2 |
| **Site 20 -** Watershed G | 1.6 | 0.6 | 2.4 | 1.2 | 0.0 | 4.4 |
| **Site 21 -** Watershed L, J | 5 | 0.9 | 2.2 | 1.1 | 0.1 | 6.0 |
| **Site 22 -** Watershed T | 1.9 | 0.1 | 2.7 | 1.4 | 0.3 | 4.4 |
| **Site 23 -** Watershed O | 1.6 | 0.6 | 2.3 | 1.3 | 0.5 | 5.2 |
| **Site 24 -** Watershed K, M, N | 2 | 0.9 | 2.7 | 1.4 | 0.1 | 4.4 |

## Raw Concentration Data

| pH (SU) | | | | | | |
|---|---|---|---|---|---|---|
| | **5/29/2007** | **7/11/2007** | **8/28/2007** | **1/8/2008** | **4/10/2008** | **6/4/2008** |
| | Storm | Base | Base | Storm | Base | Storm |
| **Site 1 -** Watershed X, Y | 7.5 | 7.5 | 7.7 | 7.5 | 7.8 | 6.6 |
| **Site 2 -** Watershed CC | 7.8 | 7.4 | 7.8 | 7.5 | 7.7 | 6.7 |
| **Site 3 -** Watershed Z | 7.6 | 7.7 | 7.7 | 7.6 | 7.8 | 6.6 |
| **Site 4 -** Watershed P, Q | 7.6 | 7.6 | 7.9 | 7.6 | 7.8 | 6.7 |
| **Site 5 -** Watershed BB, R | 7.6 | 7.4 | 7.4 | 7.5 | 7.6 | 6.9 |
| **Site 6 -** Watershed DD | 7.6 | 7.6 | 7.6 | 7.5 | 7.7 | 6.6 |
| **Site 7 -** Watersheds A, C, F | 7.4 | 7.5 | 7.4 | 7.5 | 7.4 | 6.7 |
| **Site 8 -** Watershed B, D | 7.7 | 8.0 | 7.9 | 7.9 | 7.1 | 7.9 |
| **Site 9 -** Watershed E, G | 7.7 | 7.6 | 7.3 | 8.2 | 7.0 | 7.8 |
| **Site 10 -** Watershed H | 7.4 | 7.5 | 7.4 | 7.5 | 7.5 | 6.7 |
| **Site 11 -** Watershed H | 7.5 | 7.4 | 7.2 | 7.6 | 7.5 | 6.7 |
| **Site 12 -** Watershed I | 7.4 | 7.1 | 6.9 | 7.5 | 7.3 | 6.7 |
| **Site 13 -** Watershed I | 7.4 | 7.4 | 7.2 | 7.4 | 7.3 | 6.7 |
| **Site 14 -** Watershed F | 7.4 | 7.3 | 7.2 | 7.5 | 7.5 | 6.7 |
| **Site 15 -** Watershed AA | 7.9 | 7.9 | 7.8 | 7.2 | 7.4 | 7.0 |
| **Site 16 -** Watershed S | 7.8 | 7.9 | 7.7 | 7.6 | 7.5 | 7.1 |
| **Site 17 -** Watershed S | 7.8 | 7.9 | 7.5 | 7.6 | 7.5 | 7.1 |
| **Site 18 -** Watershed W | 7.8 | 8.0 | 7.9 | 7.7 | 7.4 | 7.7 |
| **Site 19 -** Watershed U, V | 7.7 | 8.0 | 7.9 | 7.7 | 7.1 | 7.2 |
| **Site 20 -** Watershed G | 7.4 | 7.9 | 7.5 | 7.9 | 7.0 | 7.8 |
| **Site 21 -** Watershed L, J | 7.5 | 7.6 | 7.8 | 8.2 | 7.5 | 7.5 |
| **Site 22 -** Watershed T | 7.4 | 7.6 | 7.8 | 8.4 | 7.6 | 7.7 |
| **Site 23 -** Watershed O | 7.6 | 7.5 | 7.7 | 8.0 | 7.1 | 7.9 |
| **Site 24 -** Watershed K, M, N | 7.4 | 7.6 | 7.3 | 8.2 | 7.0 | 7.7 |

## Raw Concentration Data

| Temperature (Celsius) | | | | | | |
|---|---|---|---|---|---|---|
| | **5/29/2007** | **7/11/2007** | **8/28/2007** | **1/8/2008** | **4/10/2008** | **6/4/2008** |
| | Storm | Base | Base | Storm | Base | Storm |
| **Site 1 -** Watershed X, Y | 23 | 24.0 | 26.0 | 15.0 | 13.0 | 28.0 |
| **Site 2 -** Watershed CC | 26 | 23.0 | 26.0 | 15.0 | 12.0 | 26.0 |
| **Site 3 -** Watershed Z | 24 | 23.0 | 24.0 | 15.0 | 12.0 | 25.0 |
| **Site 4 -** Watershed P, Q | 23 | 24.0 | 24.0 | 14.0 | 12.0 | 26.0 |
| **Site 5 -** Watershed BB, R | 23 | 23.0 | 23.0 | 14.0 | 13.0 | 24.0 |
| **Site 6 -** Watershed DD | 23 | 25.0 | 25.0 | 15.0 | 12.0 | 24.0 |
| **Site 7 -** Watersheds A, C, F | 23 | 25.0 | 25.0 | 13.0 | 11.0 | 22.0 |
| **Site 8 -** Watershed B, D | 23 | 25.0 | 23.5 | 4.5 | 9.5 | 19.0 |
| **Site 9 -** Watershed E, G | 22.5 | 24.0 | 23.0 | 6.5 | 10.5 | 19.5 |
| **Site 10 -** Watershed H | 24 | 22.0 | 23.0 | 14.0 | 12.0 | 23.0 |
| **Site 11 -** Watershed H | 22 | 25.0 | 23.0 | 14.0 | 12.0 | 23.0 |
| **Site 12 -** Watershed I | 21 | 23.0 | 22.0 | 13.0 | 13.0 | 21.0 |
| **Site 13 -** Watershed I | 19 | 25.0 | 23.0 | 13.0 | 12.0 | 22.0 |
| **Site 14 -** Watershed F | 22 | 23.0 | 22.0 | 13.0 | 11.0 | 22.0 |
| **Site 15 -** Watershed AA | 22 | 26.5 | 25.5 | 12.0 | 8.5 | 18.0 |
| **Site 16 -** Watershed S | 20.5 | 23.0 | 21.0 | 8.0 | 7.0 | 17.0 |
| **Site 17 -** Watershed S | 24 | 22.0 | 24.0 | 6.5 | 7.5 | 17.0 |
| **Site 18 -** Watershed W | 25.5 | 21.5 | 20.5 | 6.0 | 8.0 | 17.5 |
| **Site 19 -** Watershed U, V | 23.5 | 24.0 | 21.5 | 5.0 | 8.5 | 17.5 |
| **Site 20 -** Watershed G | 20 | 21.5 | 21.5 | 7.0 | 8.0 | 17.5 |
| **Site 21 -** Watershed L, J | 21.5 | 22.5 | 21.5 | 10.5 | 9.5 | 19.0 |
| **Site 22 -** Watershed T | 19 | 21.5 | 21.5 | 10.5 | 8.0 | 19.5 |
| **Site 23 -** Watershed O | 22 | 20.5 | 20.5 | 9.0 | 10.0 | 20.0 |
| **Site 24 -** Watershed K, M, N | 21 | 25.5 | 21.5 | 7.5 | 10.5 | 19.5 |

# APPENDIX F
BENTHIC MACROINVERTEBRATE REPORT

# Big Walnut Creek Watershed Bioassessment 2007

## Introduction

Macroinvertebrate monitoring is a valuable tool to measure the ecological health of a stream. Because they are considered to be more sensitive to local conditions and respond relatively rapidly to change, benthic (bottom-dwelling) organisms are considered to be the primary tool to document the biological condition of the streams [1]. The numbers and kinds of animals present at a study site can be compared to an unimpacted reference site. For example, mayflies, stoneflies, and caddisflies (EPT taxa) are considered to be relatively sensitive to environmental disturbances. This bioassessment technique results in a single biotic index value; the higher the value, the more ecologically healthy the stream.

## Methods

Habitat Evaluation

Habitat was evaluated at each site according to the Ohio EPA method [2]. This method assigns numerical scores to various stream features (e.g. substrate type, pool depth), which are then summer into a final Qualitative Habitat Evaluation Index (QHEI) score. The maximum possible score with this method is 100.

Sample Collection (Macroinvertebrates)

Macroinvertebrate samples in this study were collected by dipnet in riffle areas where current speed approached 30 cm/sec. All samples were preserved in the field with 70% isopropanol. Spring samples were collected on April 23 and 24, and fall samples were collected on November 12 and 14, 2007. For each sampling event, duplicate samples were collected at two sites for quality control. No sample was collected from Site 11 (Heritage Lake East Inlet) in the fall because of low to no-flow conditions during the summer and fall.

Laboratory Analysis (Macroinvertebrates)

In the laboratory, a 100 organism subsample was prepared from each site by evenly distributing the animals collected in a white, gridded pan. Grids were randomly selected and all organisms within grids were removed until 100 organisms had been selected from the entire sample.

Each animal was identified to the lowest practical taxon (usually genus or species) using standard taxonomic references [4,5,6]. As each new taxon was identified, a representative specimen was preserved as a “voucher.” All voucher specimens will ultimately be deposited in the Purdue University Department of Entomology collection. The list of animals found is listed by site number in the appendix.

Data Analysis (Macroinvertebrates)

Following identification of the animals in the sample, “metrics” were calculated for each site. These metrics are based on knowledge about the sensitivity of each species to changes in environmental conditions. The macroinvertebrate data from this study were analyzed by two sets of metrics. Data were analyzed with the mIBI protocol developed by the Indiana Department of

Environmental Management [3], and an adaptation of the Ohio EPA protocol [2]. The mIBI is based on taxonomic identification to the family level, while the Ohio EPA scores are based on genus/species level of taxonomic identification. To facilitate comparisons with the QHEI, both are expressed as a percentage of the maximum possible score.

**Results**

A total of 50 macroinvertebrate genera were collected during the spring, and 65 macroinvertebrate genera during the fall. Dominant forms during the spring were midges (Chironomidae), blackfly larvae (Simuliidae), and riffle beetles (primarily *Stenelmis*). Dominant forms during the fall were caddisflies (Trichoptera), mayflies (Ephemeroptera) and midges (Chironomidae). The sediment-tolerant midge *Orthocladius obumbratus* was common and widespread during both spring and fall collections. Miller Creek (Site 12) had abundant numbers of an uncommon caddisfly (*Helicopsyche borealis*) in the fall sample. Bioassessment scores are presented in Table 1.

Table 1. Ohio EPA and mIBI bioassessment scores for macroinvertebrate data listed by site number. Included are scores for spring and fall samples, and their mean values. Scores are expressed as a percentage of the total possible score.

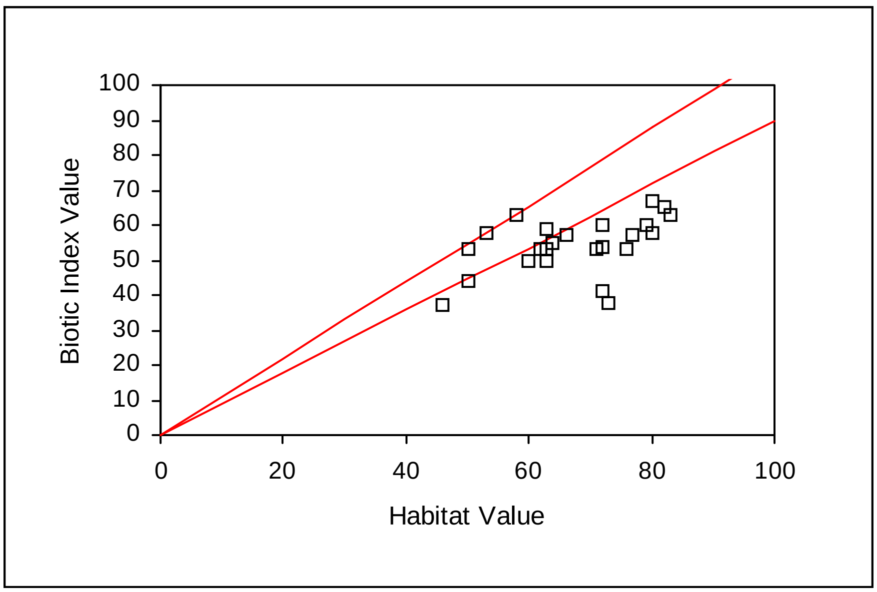
| Site Number | QHEI | Spring Ohio EPA | Fall Ohio EPA | Ohio EPA Mean Value | Spring mIBI | Fall mIBI | mIBI mean value |
|---|---|---|---|---|---|---|---|
| 1 | 46 | 47 | 27 | 37 | 53 | 33 | 43 |
| 2 | 50 | 50 | 37 | 44 | 55 | 40 | 48 |
| 3 | 64 | 50 | 60 | 55 | 53 | 70 | 62 |
| 4 | 66 | 53 | 60 | 57 | 65 | 83 | 74 |
| 5 | 63 | 53 | 53 | 53 | 60 | 60 | 60 |
| 6 | 82 | 57 | 73 | 65 | 83 | 88 | 86 |
| 7 | 80 | 43 | 73 | 58 | 70 | 85 | 78 |
| 8 | 77 | 70 | 43 | 57 | 78 | 75 | 77 |
| 9 | 79 | 60 | 60 | 60 | 83 | 70 | 77 |
| 10 | 76 | 67 | 40 | 53 | 75 | 45 | 60 |
| 11 | 62 | 53 | No sample | 53 | 50 | No sample | 50 |
| 12 | 60 | 50 | 50 | 53 | 65 | 70 | 68 |
| 13 | 63 | 57 | 60 | 59 | 60 | 73 | 67 |
| 14 | 53 | 53 | 63 | 58 | 50 | 68 | 59 |
| 15 | 72 | 47 | 73 | 60 | 70 | 80 | 75 |
| 16 | 71 | 53 | 53 | 53 | 68 | 55 | 62 |
| 17 | 72 | 27 | 50 | 41 | 45 | 53 | 49 |
| 18 | 58 | 57 | 70 | 63 | 63 | 85 | 74 |
| 19 | 80 | 63 | 70 | 67 | 80 | 73 | 77 |
| 20 | 63 | 43 | 57 | 50 | 58 | 80 | 69 |
| 21 | 72 | 57 | 50 | 54 | 70 | 80 | 75 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 22 | 73 | 57 | 23 | 38 | 65 | 10 | 38 |
| 23 | 50 | 43 | 63 | 53 | 50 | 70 | 60 |
| 24 | 83 | 53 | 73 | 63 | 63 | 80 | 72 |

**Discussion**

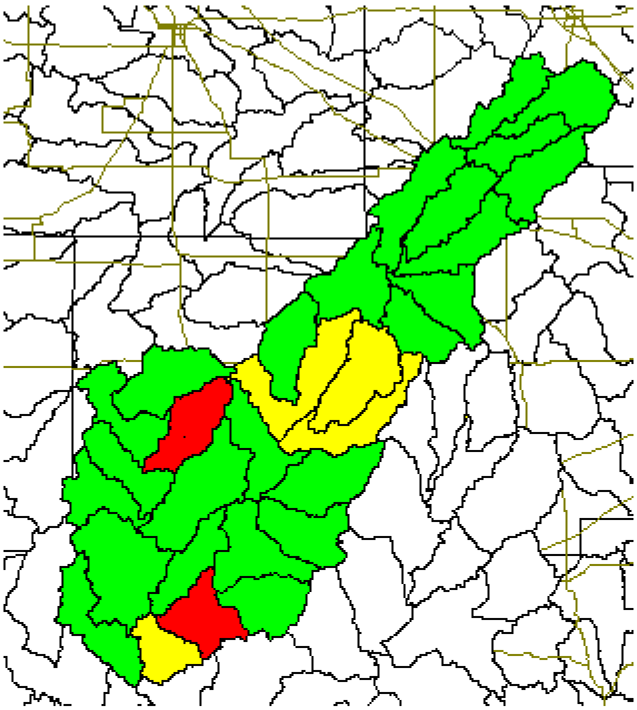
Macroinvertebrate bioassessment can indicate whether a site is biologically impaired, while the types of organisms present can give clues as to the nature of the impairment. In some cases, the cause of impairment is poor habitat quality. Aquatic life cannot thrive where habitat is lacking. The expectation is for the biotic score to be within 10% of the habitat score. If the difference is greater than 10%, water quality problems are suspected (Figure 1).

Figure 1. Relationship between Ohio EPA bioassessment scores (mean of spring and fall) and habitat scores. Sites outside of the lines may have degraded water quality.




**See Figure 1a at end of document for a larger version of this Figure.**

Figure 2. Map of sub-watersheds within the study area. The sites with the most severe biological impairment are red; sites with moderate biological impairment are yellow.



Two sites fall the farthest away from expected biotic scores and are considered to be high priority. These sub-watersheds are colored red on Figure 2. Limestone Creek (Site 22) had an average biotic index score of 38, despite this site having good habitat (QHEI score of 73). Abundance of organisms was very low in the fall. Diversity of organisms was low, with tolerant midges being dominant. Water quality at this site may be impacted by quarries within the watershed. Jones Creek (Site 17) had low scores for both spring and fall collections, although the habitat score was good (QHEI score of 72). The spring collection had low diversity, being dominated by blackfly larvae (Simuliidae), while the fall collection was elevated numbers of tolerant midges. This site experienced low-flow conditions and decreased dissolved oxygen levels during the summer of 2007.

Figure 1 illustrates that several other sites have moderately degraded biotic communities despite good to excellent habitat. These sub-watersheds are colored yellow on Figure 2. Big Walnut Creek at County Road 300 North and at Oakalla Bridge (Sites 7 and 8) both had biotic integrity score considerably lower than what would be expected. Site 7 had decreased diversity in the spring collection, with the sample being dominated by blackfly larvae. Site 8 had decreased diversity in the fall, with few mayflies present. The north inlet to Heritage Lake (Site 10) had a habitat score 0f 76, but had impaired biotic integrity in the fall collection, with a complete absence of caddisflies. Lower Deer Creek (Site 24) had the best habitat score (83) but had impaired biotic integrity in the spring collection. The sample was dominated by midge larvae (primarily the sediment tolerant *Orthocladius obumbratus*), while only one caddisfly was present.

At the upper portion of the watershed, Edlin Ditch (Site 1) and North Fork (Site 2) both had low scores for the fall collections. Both sites had large numbers of midges (*Chironomus* and *Stictochironomus*) that are tolerant of low dissolved oxygen concentrations. Although the spring scores were close to what would be expected based on the habitat values, the collections for both sites contained large numbers of riffle beetles (*Stenelmis* spp.), which can be indicative of nutrient enrichment, lack of riparian shading, or both.

Decreased habitat quality appears to be the primary influence on the biotic integrity scores of several sites. Site 14 (Plum Creek) and Site 23 (Deweese Creek) had fair habitat, with substrate embeddedness and severe bank erosion being noted. The abundance of organisms was very low for the spring collection at Plum Creek. Site 18 (Long Branch) also had fair habitat, with severe bank erosion and low channel stability. Site 11 (East Inlet to Heritage Lake) experiences no-flow conditions during dry weather.

**Conclusions**

The habitat in the Big Walnut watershed is good to excellent at most sites. Habitat could be enhanced in the upper portion of the watershed by planting riparian vegetation. Severe bank erosion is a problem at several sites. Intolerant EPT taxa were well-represented in the macroinvertebrate collections, but sediment-tolerant midges and riffle beetles associated with nutrient enrichment were also widespread. Periodic low dissolved oxygen may occur in some locations. While this may be caused by low-flow conditions resulting from dry weather, it may also be due to high water temperatures where shade is lacking.

**References**

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APPENDIX

Spring and Fall 2007 macroinvertebrate data listed by site number

Spring 2007 macroinvertebrate data

| | SITE # | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
|---|---|---|---|---|---|---|---|---|---|---|
| Diptera (flies) | | | | | | | | | | |
| | Chironomidae (midges) | | | | | | | | | |
| | Orthocladius obumbratus | 5 | 7 | 12 | 9 | 15 | 6 | 8 | 14 | 3 |
| | Cricotopus bicinctus | | 1 | 5 | 6 | 9 | | 3 | 10 | 5 |
| | C. tremulus | | | 5 | | | | | | |
| | Cardiocladus spp. | | | | | | | 2 | | |
| | Nanocladius spp. | | | | | | | | 2 | |
| | Rheocricotopus robacki | | | | | | | | | |
| | Parametriocnemus lundbecki | | | 1 | | | | | | |
| | Eukiefferiella pseudomontana | | | | | | | | | |
| | Dicrotendipes nervosus | 2 | | | | | | | | |
| | Polypedilum convictum | 3 | | 1 | | 2 | 2 | | 2 | |
| | Thienemanninyia sp. | 8 | | | | 2 | | | | 2 |
| | Rheotanytarsus spp. | 2 | 4 | | | | | | | 2 |
| | Simuliidae (blackflies) | 4 | 6 | 29 | 35 | | 6 | 43 | 12 | 3 |
| | Tabanidae (horse & deerflies) | | | 1 | | 1 | | | 1 | |
| | Empididae (aquatic dance flies) | | | | | | | | | |
| | Hemerodromia spp. | 2 | | | | | | | | |
| | Tipulidae (craneflies) | | | | | | | | | |
| | Tipula spp. | | | 2 | | | | | | |
| | Hexatoma spp. | | | | | | | | | |
| | Antocha spp. | | | | | | | 1 | | |
| | unknown diptera pupa | | | | | | 1 | 1 | | |
| | | | | | | | | | | |
| Ephemroptera | Isonychia spp. | | | | | | | | 6 | |
| (mayflies) | Baetis amplus | | | 6 | 8 | 7 | 15 | 4 | 1 | 5 |
| | B. inetercalaris | | | | | 3 | 1 | | | |
| | B. flavistriga | 4 | 2 | | | | | 4 | | |
| | B. hageni | | | | 3 | | | | | |
| | Stenonema vicarium | 1 | | 3 | 2 | | 25 | | 13 | 3 |
| | S. femoratum | | | | | | | | | |
| | S. pulchellum | | | | | | 1 | | 3 | 6 |
| | S. terminatum | | | | | | | | 1 | |
| | Stenacron interpunctatum | | 5 | | 1 | | 1 | 3 | | 3 |
| | Tricorythodes spp. | | | | | | | 3 | 3 | 45 |
| | Caenis spp. | 1 | | | 1 | 3 | 1 | | 1 | 1 |
| | Ameletus spp. | | | | | | | | | |
| | Potamanthus spp. | | | | | | | | | |
| | | | | | | | | | | |
| Trichoptera | Hydropsyche betteni | 1 | 1 | 3 | 2 | | 1 | | | |
| (caddisflies) | Ceratopsyche sparna | | 1 | 1 | | | 1 | | | 1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C. bifida | | | | 1 | | 3 | 12 | 16 | 1 |
| | Cheumatopsyche spp. | | 2 | 2 | 10 | 7 | | | 5 | 5 |
| | Chimarra obscura | | | | 1 | 1 | | | | |
| | Neureclipsis spp. | | | | | 3 | | | | |
| | Brachycentrus spp. | 1 | | | | | | | | |
| | Neophylax spp. | | | | | | | | | |
| | Ochrotrichia spp. | | | | | | | | | 1 |
| | | | | | | | | | | |
| Plecoptera | Amphinemura spp. | | | | 4 | | 5 | 3 | 5 | 1 |
| (stoneflies) | Isoperla spp. | | 3 | | 1 | 2 | 2 | 4 | 2 | 6 |
| | Acroneuria spp. | | | | | 1 | | 1 | | |
| | Chloroperlidae | | | | | | | | | |
| | | | | | | | | | | |
| Coleoptera | Stenelmis spp. | 60 | 64 | 29 | 14 | 33 | 29 | 8 | 3 | 5 |
| (beetles) | Macronychus glabratus | | | | 2 | 4 | | | | 2 |
| | Psephenus herricki | | | | | | | | | |
| | Ectopria spp. | | | | | | | | | |
| | Hydrophilidae | 1 | | | | | | | | |
| | | | | | | | | | | |
| Odonata | Argia spp. | 1 | 1 | | | | | | | |
| (damsel & dragonflies | Boyeria spp | | | | | | | | | |
| | | | | | | | | | | |
| Megaloptera | Corydalus cornutus | | | | | | | | | |
| (fishflies & dobsonflies) | | | | | | | | | | |
| | | | | | | | | | | |
| Annelida | Oligochaetes (worms) | 2 | 1 | | | 7 | | | | |
| Crustacea | Isopoda (aquatic sowbugs) | | | | | | | | | |
| | Decapoda (crayfish) | | | | | | | | | |
| Mollusca | Spaheridae | | 2 | | | | | | | |
| | Corbicula | 2 | | | | | | | | |
| | TOTAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Spring 2007, cont

| | SITE # | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **17-D** | **18** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diptera (flies) | | | | | | | | | | | |
| | Chironomidae (midges) | | | | | | | | | | |
| | Orthocladius obumbratus | 25 | 36 | 23 | 22 | 16 | 10 | 25 | 10 | 10 | 35 |
| | Cricotopus bicinctus | 1 | 4 | 12 | 10 | 6 | 1 | 2 | 1 | 1 | 4 |
| | C. tremulus | | | | | | | | | 3 | |
| | Cardiocladus spp. | | 7 | | | | | 2 | | | 4 |
| | Nanocladius spp. | | | | | | | | | | |
| | Rheocricotopus robacki | | | | | | | | | | |
| | Parametriocnemus lundbecki | | | | | | | | | | |
| | Eukiefferiella pseudomontana | | | | 8 | | | | | | 1 |
| | Dicrotendipes nervosus | | | | | 2 | | | | | |
| | Polypedilum convictum | | | | | | | | | | |
| | Thienemanninyia sp. | | | 2 | | | | 2 | | 1 | 1 |
| | Rheotanytarsus spp. | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Simuliidae (blackflies) | 7 | 3 | 1 | 14 | 8 | 33 | 2 | 73 | 56 | 12 |
| | Tabanidae (horse & deerflies) | | | | | | | 1 | | | |
| | Empididae (aquatic dance flies) | | | | | | | | | | |
| | Hemerodromia spp. | | | | | | | | | | |
| | Tipulidae (craneflies) | | | | | | | | | | |
| | Tipula spp. | 3 | 1 | 1 | | 1 | | | | | |
| | Hexatoma spp. | 2 | 1 | | | 1 | | | | | |
| | Antocha spp. | | | | | | | | | | |
| | unknown diptera pupa | | | | | | | | | | |
| | | | | | | | | | | | |
| Ephemroptera | Isonychia spp. | | | | | | | | | 1 | |
| (mayflies) | Baetis amplus | 3 | 8 | 30 | 5 | 4 | 3 | | 12 | 11 | 7 |
| | B. inetercalaris | 1 | | 9 | | | | 45 | | 1 | |
| | B. flavistriga | | 1 | | 1 | 1 | | 3 | | | |
| | B. hageni | 4 | | | | 1 | | | | | 1 |
| | Stenonema vicarium | 23 | | 1 | 2 | | | | | | 6 |
| | S. femoratum | | 8 | 1 | 3 | 2 | | 3 | | | 1 |
| | S. pulchellum | | | | | | | | | | 1 |
| | S. terminatum | | | | | | | | | | |
| | Stenacron interpunctatum | | 2 | 4 | | 1 | | | | | 1 |
| | Tricorythodes spp. | | | | | 1 | | | | | |
| | Caenis spp. | 1 | | | 1 | 7 | | | | | 2 |
| | Ameletus spp. | | 3 | | | | | | | | |
| | Potamanthus spp. | | | | | | | | | | 1 |
| | | | | | | | | | | | |
| Trichoptera | Hydropsyche betteni | | | | | | 16 | 1 | | | |
| (caddisflies) | Ceratopsyche sparna | 4 | | | | | 3 | | | | |
| | C. bifida | | | | 1 | 2 | | | | | |
| | Cheumatopsyche spp. | 1 | | | 2 | 2 | 18 | | | | 1 |
| | Chimarra obscura | 3 | | | 1 | | 8 | | | | |
| | Neureclipsis spp. | 4 | 2 | 4 | 6 | | 1 | 4 | 2 | 6 | 3 |
| | Brachycentrus spp. | | | | | | | | | | |
| | Neophylax spp. | | | | | | | 1 | | | 1 |
| | Ochotrichia spp. | | | | | | | | | | |
| | | | | | | | | | | | |
| Plecoptera | Amphinemura spp. | 10 | 5 | 3 | 3 | 4 | 4 | 1 | 1 | 6 | 11 |
| (stoneflies) | Isoperla spp. | | | 3 | 2 | | | | | | 2 |
| | Acroneuria spp. | | | | 3 | 1 | | | | | |
| | Chloroperlidae | | | 1 | | | | | | | |
| | | | | | | | | | | | |
| Coleoptera | Stenelmis spp. | 6 | 18 | 5 | 8 | 6 | 3 | 1 | 1 | 4 | 3 |
| (beetles) | Macronychus glabratus | | | | | 3 | | | | | |
| | Psephenus herricki | 2 | | | 7 | | | 5 | | | |
| | Ectopria spp. | | | | | | | 1 | | | |
| | Hydrophilidae | | | | | | | | | | |
| | | | | | | | | | | | |
| Odonata | Argia spp. | | | | | | | | | | |
| (damsel & dragonflies | Boyeria spp | | | | | | | | | | 1 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Megaloptera | Corydalus cornutus | | | | | | | | | | |
| (fishflies & dobsonflies) | | | | | | | | | | | |
| | | | | | | | | | | | |
| Annelida | Oligochaetes (worms) | | | | | | | | | | |
| Crustacea | Isopoda (aquatic sowbugs) | | 1 | | 1 | | | 1 | | | 1 |
| | Decapoda (crayfish) | | | | | | | | | | |
| Mollusca | Spaheridae | | | | | | | | | | |
| | Corbicula | | | | | | | | | | |
| | TOTAL | 100 | 100 | 100 | 100 | 69 | 100 | 100 | 100 | 100 | 100 |

| | SITE # | **19** | **20** | **21** | **22** | **22-D** | **23** | **24** |
|---|---|---|---|---|---|---|---|---|
| Diptera (flies) | | | | | | | | |
| | Chironomidae (midges) | | | | | | | |
| | Orthocladius obumbratus | 17 | 6 | 12 | 23 | 17 | 14 | 25 |
| | Cricotopus bicinctus | 4 | | 17 | 2 | 7 | 10 | 6 |
| | C. tremulus | | | | 6 | | 2 | 2 |
| | Cardiocladus spp. | | 3 | | | | | |
| | Nanocladius spp. | | | | | | | |
| | Rheocricotopus robacki | | 1 | 2 | | | | |
| | Parametriocnemus lundbecki | | | | | | | |
| | Eukiefferiella pseudomontana | | | | | | | |
| | Dicrotendipes nervosus | | | | | | | |
| | Polypedilum convictum | | | 2 | | | | 2 |
| | Thienemanninyia sp. | 5 | 2 | 3 | | 1 | | |
| | Rheotanytarsus spp. | | | | | | | |
| | Simuliidae (blackflies) | 4 | 60 | | 14 | 26 | 32 | 20 |
| | Tabanidae (horse & deerflies) | | | | | | | |
| | Empididae (aquatic dance flies) | | | | | | | |
| | Hemerodromia spp. | | 2 | | | | | |
| | Tipulidae (craneflies) | | | | | | | |
| | Tipula spp. | | | | | | | |
| | Hexatoma spp. | | 2 | | | | | |
| | Antocha spp. | | 1 | | | | | |
| | unknown diptera pupa | | | | | | | |
| | | | | | | | | |
| Ephemroptera | Isonychia spp. | | | 1 | 3 | | | 1 |
| (mayflies) | Baetis amplus | 29 | 10 | 2 | 11 | 5 | 8 | 11 |
| | B. inetercalaris | 1 | | | 25 | 27 | 17 | 7 |
| | B. flavistriga | | | | 2 | | 1 | |
| | B. hageni | | | | 2 | | | |
| | Stenonema vicarium | 1 | 3 | 3 | 4 | | | 3 |
| | S. femoratum | | | 8 | | | | |
| | S. pulchellum | | | | | | | |
| | S. terminatum | | | | | | | |
| | Stenacron interpunctatum | 1 | | 5 | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tricorythodes spp. | | | | | | | | 9 |
| | Caenis spp. | | | | 9 | | | | |
| | Ameletus spp. | | | | | | | | |
| | Potamanthus spp. | | | | | | | | |
| | | | | | | | | | |
| Trichoptera | Hydropsyche betteni | | | | | | | | |
| (caddisflies) | Ceratopsyche sparna | | | | | | | | |
| | C. bifida | | | | | | | | |
| | Cheumatopsyche spp. | | 2 | 1 | 8 | 2 | 2 | | 1 |
| | Chimarra obscura | | 3 | 1 | 2 | | | | |
| | Neureclipsis spp. | | 2 | 3 | | | 1 | | |
| | Brachycentrus spp. | | | | | | | | |
| | Neophylax spp. | | | | | | | | |
| | Ochotrichia spp. | | | | | | | | |
| | | | | | | | | | |
| Plecoptera | Amphinemura spp. | | 15 | 5 | 2 | 4 | 7 | 2 | 2 |
| (stoneflies) | Isoperla spp. | | 1 | | | | 2 | | |
| | Acroneuria spp. | | 9 | | 8 | | | 1 | 1 |
| | Chloroperlidae | | | | | | | | |
| | | | | | | | | | |
| Coleoptera | Stenelmis spp. | | 6 | | 13 | 1 | 1 | 13 | 8 |
| (beetles) | Macronychus glabratus | | | | 1 | | | | |
| | Psephenus herricki | | | | | | | | |
| | Ectopria spp. | | | | | | | | |
| | Hydrophilidae | | | | | | | | |
| | | | | | | | | | |
| Odonata | Argia spp. | | | | | | | | |
| (damsel & dragonflies | Boyeria spp | | | | | | | | |
| | | | | | | | | | |
| Megaloptera | Corydalus cornutus | | | | | 1 | 2 | | 2 |
| (fishflies & dobsonflies) | | | | | | | | | |
| | | | | | | | | | |
| Annelida | Oligochaetes (worms) | | | | 1 | | | | |
| Crustacea | Isopoda (aquatic sowbugs) | | | | 1 | | 1 | | |
| | Decapoda (crayfish) | | | | | | 1 | | |
| Mollusca | Spaheridae | | | | | | | | |
| | Corbicula | | | | | | | | |
| | TOTAL | | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Fall 2007 Macroinvertebrate Data

| | | SITE # | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diptera (flies) | | | | | | | | | | | |
| | Chironomidae (midges) | | | | | | | | | | |
| | Procladius spp. | | 11 | 5 | | | | | | | |
| | Thienemanninyia spp. | | | | 2 | 9 | 7 | | 1 | | 6 |
| | Orthocladius obumbratus | | | 3 | 8 | | 32 | 10 | 9 | 7 | 15 |
| | Corynoneura spp. | | | | | | | | | | |
| | Cricotopus bicinctus | | | | | | | | | | 10 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nanocladius spp. | | | 2 | 5 | | | | | |
| | Eukiefferiella pseudomontana | | | 1 | 1 | | | | | |
| | E. bavarica | | | | | | | | | |
| | Parakieferiellla spp. | | | | | 2 | | | | |
| | Parametriocenemus spp. | | | | | | | | | |
| | Rheocricotopous robacki | | | | | | | | | |
| | Thienemanniella xena | | | | 1 | | | | | |
| | Dicrotendipes neomodestus | 8 | | | 1 | | | | | |
| | Chironomus spp. | 28 | 8 | | 2 | | | | | 11 |
| | Stictochironomus spp. | 17 | 50 | | 2 | 2 | | | | |
| | Cryptochironomus fulvus | 3 | | | | | | | | |
| | Microtendipes caelum | 3 | | | | | | | | |
| | Polypedilum convictum | | | 1 | 1 | 2 | | | 1 | |
| | P.fallax | | | | | | | | | |
| | Microspectra polita | | | | | | 2 | 1 | | |
| | Rheotanytarsus exiguus | | | | | | | | | |
| | Tanytarisus spp. | | | | | | | | | |
| | Paratanytarsus spp. | | | | | | | | | |
| | Simuliidae (blackflies) | | | | 1 | | | | | |
| | Ceratopogonidae (biting midges) | | | | | | | | | |
| | Tabanidae (hrose & deerllies) | | | | | | | | | |
| | Empididae (aquatic danceflies) | | | | | | | | | |
| | Hemerodromia | | | | | | | 1 | | |
| | Tipulidae (craneflies) | | | | | | | | | |
| | Tipula | | 1 | 2 | | 3 | | | | |
| | Hexatoma | | | | | | | | | |
| | Pseudolimnophila | | | | | | | | | |
| | Antocha | | | | | | | | | |
| | | | | | | | | | | |
| Ephemeroptera | Isonychia spp. | | | | 10 | 1 | 18 | 3 | 3 | 3 |
| (mayflies) | Baetis spp. | | | | | | | | | |
| | B. inetercalaris | | | | | | | | | |
| | B. flavistriga | | | 1 | | | | | | |
| | Stenonema vicarium | | 2 | 3 | 8 | | 18 | 22 | | 5 |
| | S. femoratum | | 3 | 1 | | 3 | 2 | | | |
| | S. pulchellum | | | | | | | | 1 | 1 |
| | S. terminatum | | | | | | 3 | 2 | | 9 |
| | Stenacron interpunctatum | | 9 | | | 1 | 4 | 2 | | 3 |
| | Tricorythodes spp. | | | | | | 1 | 17 | | 8 |
| | Caenis spp. | 5 | 2 | 1 | 3 | 15 | 1 | | | 3 |
| | Potamanthus spp. | | | | | | | 1 | | |
| | | | | | | | | | | |
| Trichoptera | Hydropsyche betteni | | | 12 | | | | | | |
| (caddisflies) | Ceratopsyche sparna | | | 1 | | | | | | |
| | C. bifida | 1 | 1 | 4 | | | 3 | 20 | 49 | |
| | Cheumatopsyche spp. | | 3 | 54 | 22 | 15 | 22 | 9 | 28 | 2 |
| | Chimarra obscura | | | 3 | 31 | 6 | 8 | 6 | 8 | 1 |
| | Polycentropis spp. | | | | | | | | | 1 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Helicopsyche borealis | | | | | | | | | | | |
| | Limnephilidae | | | | | | | | | | | |
| | Ochrotrichia spp. | | | | | | | | | | | 2 |
| | | | | | | | | | | | | |
| Plecoptera | Taeniopteryx spp. | | | | | | 2 | | 1 | 1 | 1 | 7 |
| (stoneflies) | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Coleoptera | Stenelmis spp. | | | 20 | 11 | 2 | | 3 | 5 | 5 | | 2 |
| (beetles) | Dubiraphia spp. | | | 1 | | | | | | | | |
| | Macronychus glabratus | | | | | | | | | | | 3 |
| | Psephenus heriicki | | | | | | | 1 | | | | |
| | Berosus spp. | | | 1 | 1 | | | 1 | | | | |
| | | | | | | | | | | | | |
| Odonata | Argia spp. | | | 1 | 1 | | 1 | 1 | 1 | | | 5 |
| (damsel & | Hetaerina spp. | | | | | | | | | | 1 | |
| dragonflies) | Plathelmis lydia | | | | | | | | | | | 1 |
| | Erpetogomphus designatus | | | | | | | | | | | 1 |
| | | | | | | | | | | | | |
| Megaloptera | Corydalus cornutus | | | | | | | | 1 | | | |
| (dobson & fishflies) | Sialis spp. | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Oligochaetes (worms) | | | | | | | | | | | | |
| Turbellaria (planarians) | | | | | | 2 | | 1 | | | 1 | |
| Amphipoda (scuds) | | | | | | | | 4 | | | | 1 |
| Isopoda (aquatic sowbugs) | | Lirceus spp. | | | | | | | | | | |
| | | Caecedotea spp. | | | | | | | | | | |
| Hirudinea (leeches) | | | | 1 | | | | | | | | |
| Mollusca | Physella | | | | | | | | | | | |
| | Sphaeeridae | | | | | | | | | | | |
| | | | | | | | | | | | | |
| TOTAL | | | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Fall 2007, cont.

| | | | SITE # | **10** | **12** | **13** | **14** | **15** | **16** | **17** | **18** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diptera (flies) | | | | | | | | | | | |
| | Chironomidae (midges) | | | | | | | | | | |
| | Procladius spp. | | | | | | | | | | |
| | Thienemanninyia spp. | | | 8 | 3 | | 12 | 1 | 4 | 18 | 4 |
| | Orthocladius obumbratus | | | | 9 | 26 | 21 | 5 | 2 | 9 | |
| | Corynoneura spp. | | | 9 | | | | 1 | 4 | 3 | |
| | Cricotopus bicinctus | | | | | | | | | | |
| | Nanocladius spp. | | | 14 | | 4 | 2 | | | | |
| | Eukiefferiella pseudomontana | | | | | | | 1 | | | 2 |
| | E. bavarica | | | | | | | | 8 | | |
| | Parakieferiellla spp. | | | | | | | | | | |
| | Parametriocenemus spp. | | | | | | | 4 | 26 | 21 | 2 |
| | Rheocricotopous robacki | | | 11 | | | | | | | |
| | Thienemanniella xena | | | | 4 | | 2 | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Dicrotendipes neomodestus | | | | 1 | | | | |
| | Chironomus spp. | | | | | | | | |
| | Stictochironomus spp. | 8 | | | 2 | | | 3 | |
| | Cryptochironomus fulvus | | | | 2 | | | | |
| | Microtendipes caelum | 8 | | | | | | 9 | 1 |
| | Polypedilum convictum | | | | 2 | | | | |
| | P.fallax | 3 | | | | | | | |
| | Microspectra polita | | | | | | | | |
| | Rheotanytarsus exiguus | | | | | | | | |
| | Tanytarisus spp. | | 1 | 2 | | | | | |
| | Paratanytarsus spp. | | | | | | | | |
| | Simuliidae (blackflies) | | | | | | | | |
| | Ceratopogonidae (biting midges) | | | | | | | 3 | |
| | Tabanidae (hrose & deerllies) | | | | 1 | | | | |
| | Empididae (aquatic danceflies) | | | | | | | | |
| | Hemerodromia | | | | | | | | |
| | Tipulidae (craneflies) | | | | | | | | |
| | Tipula | 4 | | | 5 | | | 4 | 2 |
| | Hexatoma | 1 | | | | | | | |
| | Pseudolimnophila | 2 | | | | | | | |
| | Antocha | | | | | 1 | | | 1 |
| | | | | | | | | | |
| Ephemeroptera | Isonychia spp. | | | 1 | 5 | 3 | 1 | | 4 |
| (mayflies) | Baetis spp. | | | 1 | | | | 1 | |
| | B. inetercalaris | | | | 2 | | | | |
| | B. flavistriga | | | | | | | | |
| | Stenonema vicarium | 6 | | 1 | 6 | 16 | 4 | 4 | 20 |
| | S. femoratum | 2 | | 1 | 1 | 15 | | 1 | 4 |
| | S. pulchellum | | | | | | | | |
| | S. terminatum | | | | | | | | |
| | Stenacron interpunctatum | 2 | | 1 | | 8 | 4 | 4 | 4 |
| | Tricorythodes spp. | | | | | 1 | | | |
| | Caenis spp. | 2 | | | 9 | 1 | | 1 | 2 |
| | Potamanthus spp. | | | | | | | | |
| | | | | | | | | | |
| Trichoptera | Hydropsyche betteni | | | 1 | | 2 | | | |
| (caddisflies) | Ceratopsyche sparna | | | | | 3 | | | |
| | C. bifida | | 5 | 3 | | | | | |
| | Cheumatopsyche spp. | | 4 | 21 | 13 | 33 | 24 | 8 | 36 |
| | Chimarra obscura | | 23 | 10 | 6 | 2 | 9 | 2 | 11 |
| | Polycentropis spp. | | | | 1 | | | | 1 |
| | Helicopsyche borealis | | 35 | | | | | | |
| | Limnephilidae | | | | | 2 | | | |
| | Ochrotrichia spp. | | | | | | | | |
| | | | | | | | | | |
| Plecoptera | Taeniopteryx spp. | 3 | | 16 | 3 | | | 1 | |
| (stoneflies) | | | | | | | | | |
| | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Coleoptera | Stenelmis spp. | 6 | 1 | 3 | 1 | 1 | 2 | 4 | 1 |
| (beetles) | Dubiraphia spp. | | 1 | | | | | | |
| | Macronychus glabratus | | | 2 | | | | | 1 |
| | Psephenus heriicki | 10 | 13 | 2 | 1 | | 3 | 1 | 3 |
| | Berosus spp. | | | | | | | | |
| | | | | | | | | | |
| Odonata | Argia spp. | | 1 | 1 | 1 | | | | |
| (damsel & | Hetaerina spp. | | | 1 | | | | | |
| dragonflies) | Plathelmis lydia | | | | | | | | |
| | Erpetogomphus designatus | | | | | | | | |
| | | | | | | | | | |
| Megaloptera | Corydalus cornutus | | | | | | | 1 | 1 |
| (dobson & fishflies) | Sialis spp. | | | 1 | | | | | |
| | | | | | | | | | |
| Oligochaetes (worms) | | 1 | | 1 | 1 | | | 1 | |
| Turbellaria (planarians) | | | | 1 | | | | | |
| Amphipoda (scuds) | | | | | | | | | |
| Isopoda (aquatic sowbugs) | Lirceus spp. | | | | | | 8 | | |
| | Caecedotea spp. | | | | | | | | |
| Hirudinea (leeches) | | | | | | | | | |
| Mollusca | Physella | | | | | | 1 | | |
| | Sphaeeridae | | | | | | | 1 | |
| TOTAL | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Fall 2007, cont.

| | SITE # | **19** | **20** | **21** | **22** | **23** | **24** | **20 D** | **24 D** |
|---|---|---|---|---|---|---|---|---|---|
| Diptera (flies) | | | | | | | | | |
| | Chironomidae (midges) | | | | | | | | |
| | Procladius spp. | | | | | | | | |
| | Thienemanninyia spp. | 2 | 1 | | | 4 | 4 | 2 | 2 |
| | Orthocladius obumbratus | 28 | | 5 | 18 | 16 | 7 | | 12 |
| | Corynoneura spp. | | | | 2 | | 1 | | |
| | Cricotopus bicinctus | 3 | | | 4 | | | | 3 |
| | Nanocladius spp. | | | | | | | | |
| | Eukiefferiella pseudomontana | | | | | | | | |
| | E. bavarica | | | | | 4 | | | |
| | Parakieferiellla spp. | | | | | | | | |
| | Parametriocenemus spp. | | 1 | | 5 | 6 | 1 | 5 | 4 |
| | Rheocricotopous robacki | | | | | | | | |
| | Thienemanniella xena | 1 | 1 | | 3 | | | 1 | |
| | Dicrotendipes neomodestus | | | | | 2 | 2 | 3 | 1 |
| | Chironomus spp. | 1 | | | | | | | |
| | Stictochironomus spp. | | | | | | | | |
| | Cryptochironomus fulvus | | | | | | | | |
| | Microtendipes caelum | | 1 | | | | 1 | 4 | |
| | Polypedilum convictum | | | | | | | | |
| | P.fallax | | | | | | | | |
| | Microspectra polita | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Rheotanytarsus exiguus | | | | | 4 | 1 | | |
| | Tanytarisus spp. | | | | | | | | |
| | Paratanytarsus spp. | | 2 | | 2 | | | | 1 |
| | Simuliidae (blackflies) | | | | | 3 | | | |
| | Ceratopogonidae (biting midges) | | | | | | | | |
| | Tabanidae (hrose & deerllies) | | | | | | | 1 | |
| | Empididae (aquatic danceflies) | | | | | | | | |
| | Hemerodromia | | | | | | 1 | | 1 |
| | Tipulidae (craneflies) | | | | | | | | |
| | Tipula | 1 | | 2 | | | | | |
| | Hexatoma | | | | | | | | |
| | Pseudolimnophila | | | | | | | | |
| | Antocha | | | | | | | | |
| | | | | | | | | | |
| Ephemeroptera | Isonychia spp. | 9 | 1 | 4 | | 38 | 1 | | 2 |
| (mayflies) | Baetis spp. | | | | | | | | |
| | B. inetercalaris | | | | | | | | |
| | B. flavistriga | | | | | | | | |
| | Stenonema vicarium | 12 | 6 | 5 | | 1 | 21 | 5 | 16 |
| | S. femoratum | 1 | 4 | 2 | | | | 3 | 9 |
| | S. pulchellum | 2 | | | | | | | |
| | S. terminatum | | | | | | 7 | | |
| | Stenacron interpunctatum | 4 | 3 | 1 | | 2 | 3 | 29 | 2 |
| | Tricorythodes spp. | 1 | | | | | 3 | | 16 |
| | Caenis spp. | 1 | | | | | | | |
| | Potamanthus spp. | | | | | | | | |
| | | | | | | | | | |
| Trichoptera | Hydropsyche betteni | 1 | | | | 1 | 1 | | |
| (caddisflies) | Ceratopsyche sparna | | | | | | | | 1 |
| | C. bifida | 3 | | 2 | | | | | 2 |
| | Cheumatopsyche spp. | 5 | 39 | 43 | | 12 | 4 | 23 | 3 |
| | Chimarra obscura | 1 | 38 | 26 | | 1 | | 22 | |
| | Polycentropis spp. | | | | | 1 | 2 | | 3 |
| | Helicopsyche borealis | | | | | | | | |
| | Limnephilidae | | | | | | | | |
| | Ochrotrichia spp. | | | | | | 4 | | 1 |
| | | | | | | | | | |
| Plecoptera | Taeniopteryx spp. | 9 | | | | | 16 | | 9 |
| (stoneflies) | | | | | | | | | |
| | | | | | | | | | |
| Coleoptera | Stenelmis spp. | 6 | | 7 | 2 | 3 | 9 | | 5 |
| (beetles) | Dubiraphia spp. | | | | | | | | |
| | Macronychus glabratus | | | | | | 1 | 1 | 3 |
| | Psephenus heriicki | 5 | | 1 | | | 1 | | |
| | Berosus spp. | | | | | | | | |
| | | | | | | | | | |
| Odonata | Argia spp. | 1 | | 2 | | | | | 1 |
| (damsel & | Hetaerina spp. | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| dragonflies) | Plathelmis lydia | | | | | | | | | | |
| | Erpetogomphus designatus | | | | | | | | | | |
| | | | | | | | | | | | |
| Megaloptera | Corydalus cornutus | | | 1 | | | | | 1 | | 2 |
| (dobson & fishflies) | Sialis spp. | | | | | | | | | | |
| | | | | | | | | | | | |
| Oligochaetes (worms) | | | | 2 | 3 | | 4 | 1 | 8 | | 1 |
| Turbellaria (planarians) | | | | | | | | | | | |
| Amphipoda (scuds) | | | | | | | | | | | |
| Isopoda (aquatic sowbugs) | | Lirceus spp. | | | | | | | | 1 | |
| | | Caecedotea spp. | | | | | | 1 | | | |
| Hirudinea (leeches) | | | | | | | | | | | |
| Mollusca | Physella | | | | | | | | | | |
| | Sphaeeridae | | | | | | 1 | | | | |
| | | | | | | | | | | | |
| TOTAL | | | | 100 | 100 | 100 | 41 | 100 | 100 | 100 | 100 |

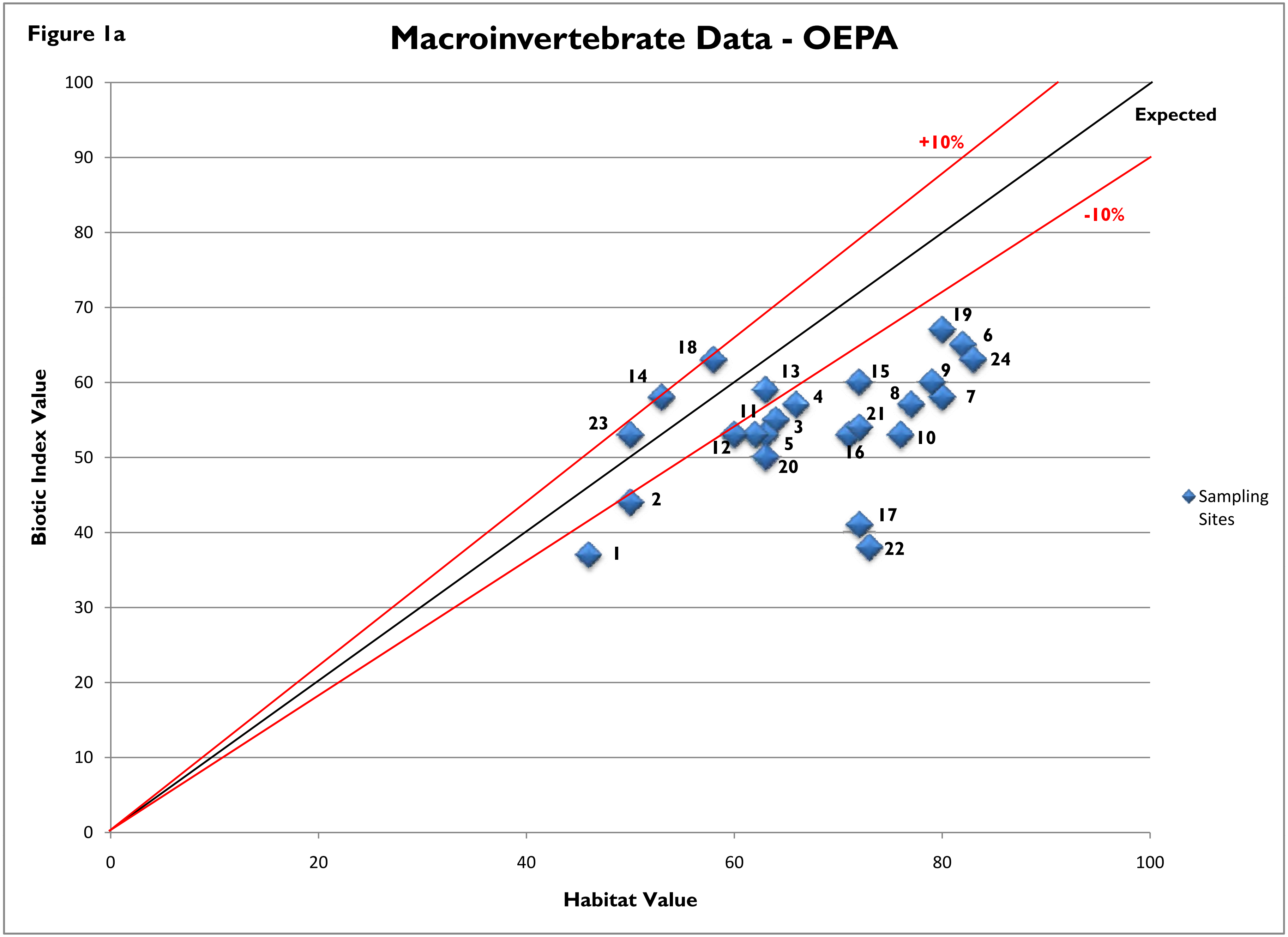

Figure 1a
Macroinvertebrate Data - OEPA
Biotic Index Value
Habitat Value
Expected
+10%
-10%
Sampling Sites
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
1
2
3
4
5
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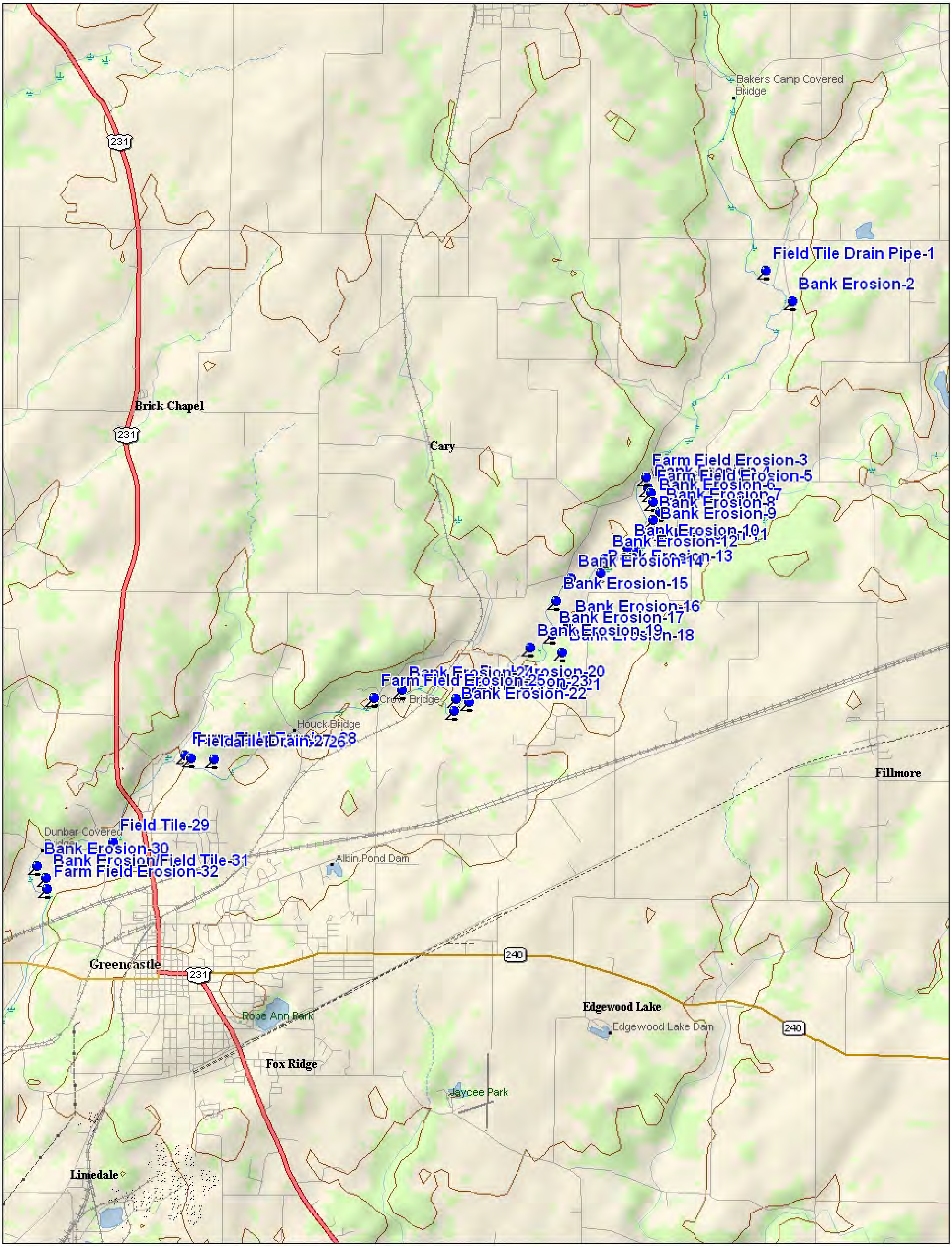
# APPENDIX G

INDIANA SMALLMOUTH CONSERVATION
FLOAT TRIPS

| GPS Coordinates | Issues/Problems |
|---|---|
| N39° 43.646', W86° 46.326' | Field tile drain pipe |
| N39° 43.424', W86° 46.070' | Bank erosion |
| N39° 42.149', W86° 47.449' | Farm field erosion |
| N39° 42.071', W86° 47.428' | Bank erosion |
| N39° 42.038', W86° 47.403' | Farm field erosion |
| N39° 41.972', W86° 47.384' | Bank erosion |
| N39° 41.902', W86° 47.314' | Bank erosion |
| N39° 41.842', W86° 47.379' | Bank erosion |
| N39° 41.766', W86° 47.371' | Bank erosion |
| N39° 41.643', W86° 47.624' | Bank erosion |
| N39° 41.615', W86° 47.540' | Bank erosion |
| N39° 41.563', W86° 47.826' | Bank erosion |
| N39° 41.457', W86° 47.873' | Bank erosion |
| N39° 41.427', W86° 48.147' | Bank erosion |
| N39° 41.260', W86° 48.293' | Bank erosion |
| N39° 41.094', W86° 48.174' | Bank erosion |
| N39° 41.020', W86° 48.326' | Bank erosion |
| N39° 40.891', W86° 48.233' | Bank erosion |
| N39° 40.922', W86° 48.530' | Bank erosion |
| N39° 40.626', W86° 49.067' | Bank erosion |
| N39° 40.533', W86° 49.109' | Bank erosion |
| N39° 40.470', W86° 49.245' | Bank erosion |
| N39° 40.554', W86° 49.223' | Bank erosion |
| N39° 40.620', W86° 49.733' | Bank erosion |
| N39° 40.1243', W86° 51.5354' | Severe bank erosion, crop damage, |
| N39° 40.1154', W86° 51.0969' | Severe bank erosion, sand damage to farm field, crop damage, log jam |
| N39° 37.656', W86° 53.946' | Log jam, stripped sod banks |
| N39° 38.420', W86° 53.261' | Severe bank erosion, sand damage to farm field |
| N39° 35.1644', W86° 56.3578' | Debris in chokepoint, fallen trees, bank erosion, small log jam |
| N39° 35.3766', W86° 56.4005' | Small channel where debris gets pushed into creek, scrap metal, old car |
| N39° 35.4820', W86° 56.4122' | Riprap, heavy sediment runoff above riprap and has created a silt bar |
| N39° 35.6426', W86° 56.4434' | Bank erosion, exposed clay |
| N39° 35.7050', W86° 56.5085' | Log jam, stripped sod banks |
| N39° 36.0341', W86° 56.4751' | Split with island, large trees down |

| GPS Coordinates (cont) | Issues/Problems |
|---|---|
| N39° 36.1305', W86° 56.4127' | Bank cutouts, bank erosion, crops planted near/up to edge of bank, large trees down on bank |
| N39° 36.3269', W86° 56.3152' | Severe bank erosion, creek channel with erosion, |
| N39° 36.3911', W86° 56.3586' | Bank erosion, large trees down |
| N39° 36.1609', W86° 57.0200' | Trees down, potential log jam |
| N39° 36.6590', W86° 56.7319' | High bank erosion, down trees |
| N39° 36.8787', W86° 56.7450' | High bank erosion, down trees |
| N39° 37.0250', W86° 56.7406' | Old stone bridge piling, bank erosion, large trees down |
| N39° 37.3037', W86° 56.3953' | New channel cut around log jam, small log jam, high bank erosion, crops planted near/up to edge of bank, crops falling into creek |
| N39° 37.1789', W86° 55.9777' | Down trees |
| N39° 37.1803', W86° 55.8796' | Trees down covering creek, high bank erosion |
| N39° 37.3969', W86° 55.2712' | High bank erosion, farming up to erosion |
| N39° 34.797', W86° 56.314' | Bank erosion |
| N39° 34.727', W86° 56.294' | Bank erosion |
| N39° 34.407', W86° 56.419 | Bank erosion |
| N39° 34.223', W86° 56.613' | Bank erosion |
| N39° 34.126', W86° 56.681' | Bank erosion along farmers earthen retaining wall |
| N39° 34.058', W86° 56.784' | Tree/debris pile up |
| N39° 34.132', W86° 56.884' | Bank erosion |
| N39° 34.005', W86° 56.887' | Bank erosion |
| N39° 33.947', W86° 56.792' | Bank erosion |
| N39° 33.662', W86° 56.478' | Severe bank erosion |
| N39° 33.517', W86° 56.691' | Bank erosion |
| N39° 33.459', W86° 56.960' | Bank erosion - partially fixed with riprap |
| N39° 33.003', W86° 58.995' | New trees |
| N39° 32.889', W86° 59.024' | Bank erosion, new trees |
| N39° 32.801', W86° 59.046' | New trees |
| N39° 32.560', W86° 59.085' | Sycamores with exposed roots |
| N39° 32.560', W86° 58.905' | Bank erosion, logs |
| N39° 32.196', W86° 58.396' | Root balls |
| N39° 32.034', W86° 58.360' | Trees down, bank erosion |
| N39° 32.037', W86° 58.221' | Outside bend |
| N39° 31.679', W86° 58.069' | High erosion |
| N39° 31.280', W86° 57.553' | Bank erosion, pipe exposed |





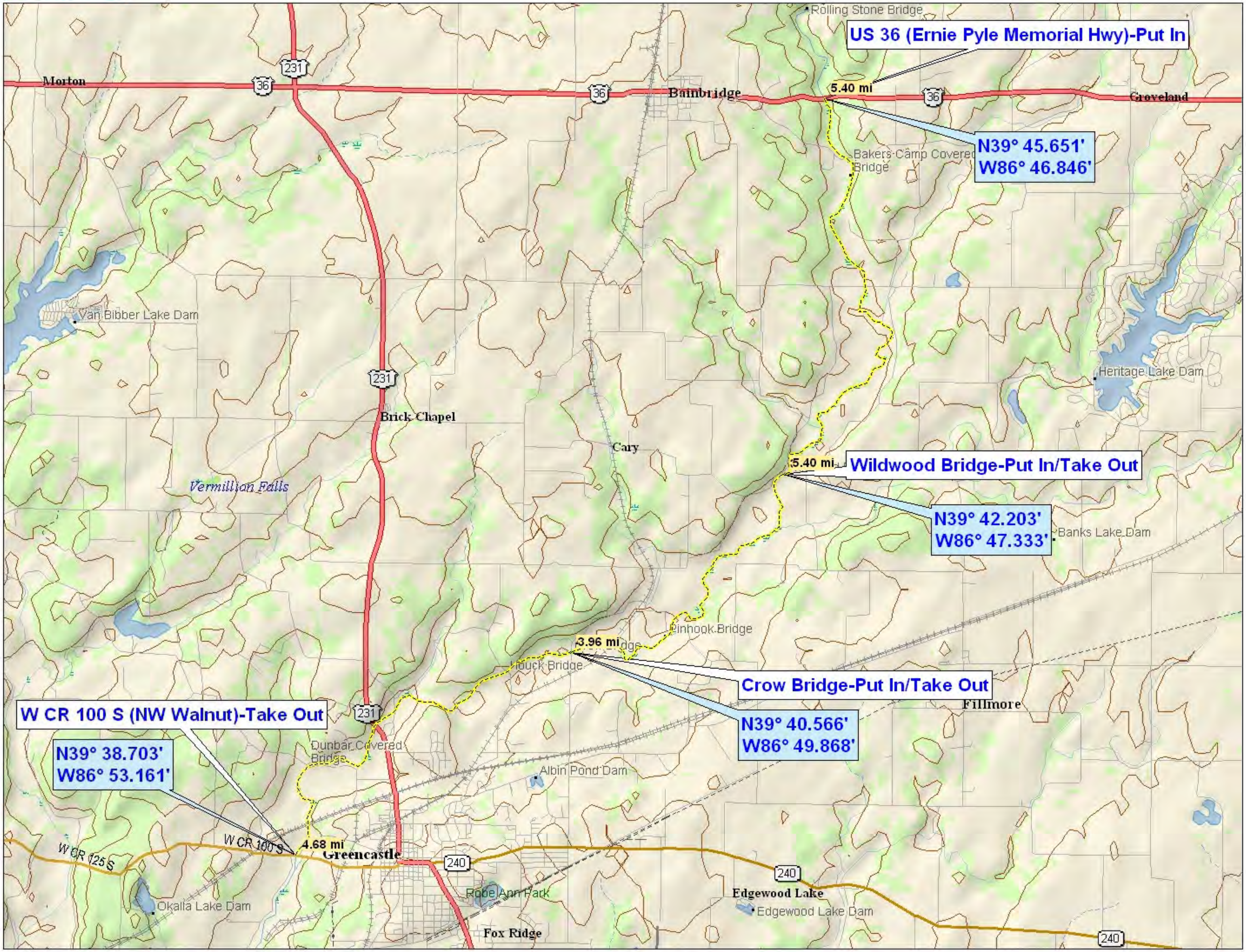

MN (0.0° W)

0 ½ 1 1½ 2 mi

Data Zoom 11-5

DELORME

Topo USA® 5.0






MN (0.0° W)

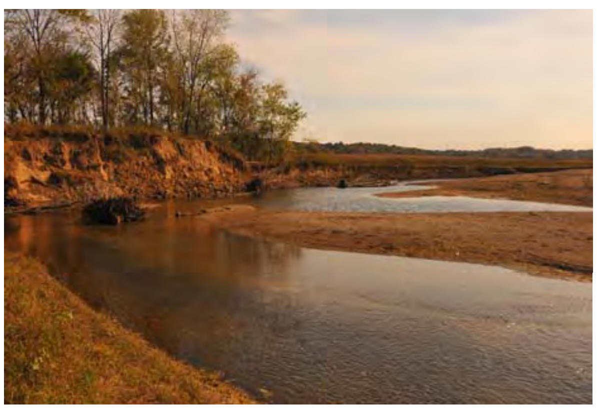
0 ½ 1 1½ 2 2½ mi

Data Zoom 11-0


05/26/2007





























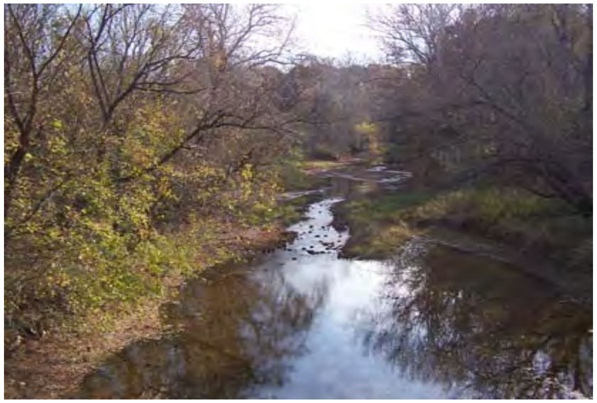


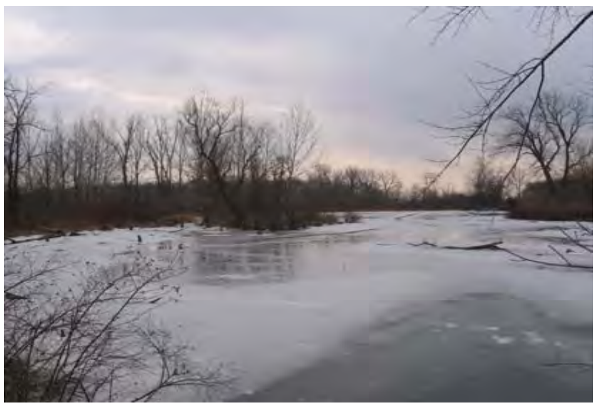




# APPENDIX H
## WATERSHED PHOTOS

Photos of good areas seen throughout the Big Walnut Creek Watershed during the windshield surveys.





Photos of problems seen throughout the Big Walnut Creek Watershed during the windshield surveys.









Photos of problems seen throughout the Big Walnut Creek Watershed during the windshield surveys.